LIFETIME

LIFECYCLE

Design Construction Management Recovery

Lifetime Engineering

A Visionary View

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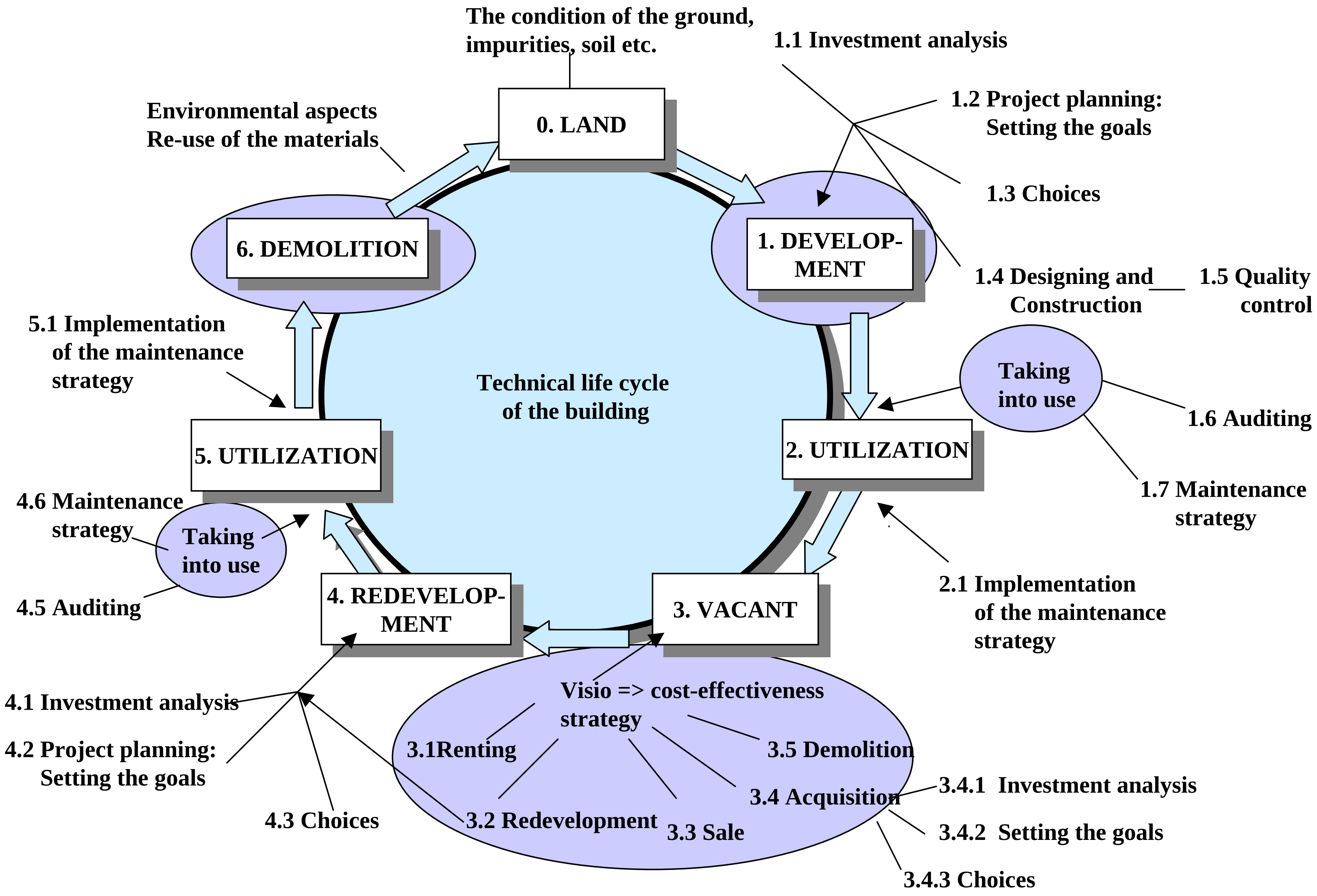
LIFETIME ENGINEERING

- **Lifetime engineering is a theory and practice of predictive and integrated long-term investment planning, design, management of the use, maintenance planning and end-of-life management of facilities**

- **With the aid of lifetime engineering we can control and optimise the design and management of facilities corresponding to the objectives of owners, users and society.**

- **The objective of Lifetime Engineering is an optimised Lifetime Quality of facilities**

Life cycle of a building



CONTENT OF THE LIFETIME ENGINEERING

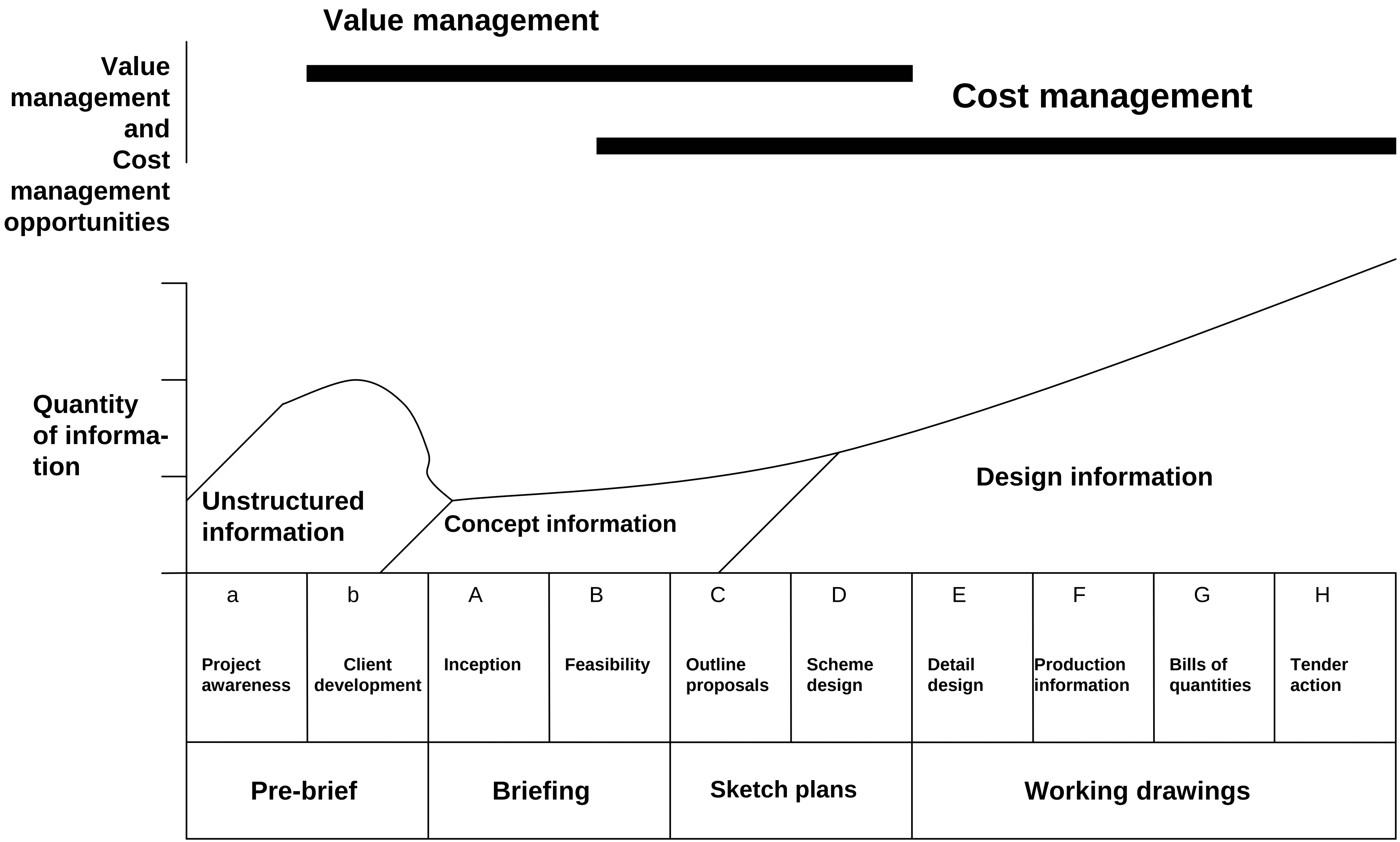
- Lifetime investment planning
- Integrated lifetime design
- Integrated lifetime procurement (lifetime contract)
- Integrated lifetime management and maintenance planning
- Rehabilitation and modernisation
- End-of Life Management:
    - Recovery, Reuse
    - Recycling and
    - Disposal

Visions of the future Lifetime Engineering

- The generic criteria of Sustainable Building are followed
  - in all phases of the life cycle
- The lifetime management is:
  - predictive: future usability, economy, ecology and cultural aspects are evaluated, modelled and used as criteria for selections between alternative solutions and products in all phases
  - creative: alternative solutions and technologies are created and found at all phases of the process
  - optimising: comparisons between alternative solutions and products made with rational methods applying the criteria, which correspond to the generic criteria on techno-economic and architectural level

Optimising Lifetime Management and design Process

[John Kelly and Steven Male, Value Management in Design and Construction. E&FN SPON London. 1993.]



LIFETIME ENGINEERING PROCESS

- ***Value engineering and management***
  - a service
    - that utilises structured functional analysis and
    - other problem solving tools and technques in order to
    - determine explicitely s client`s needs and wants
    - related **to both cost and worth**
- ***Cost management***
  - a servgice that
    - synthesises traditional quantity surveying skills with
    - structured cost cost reduction or
    - substitution procedures using multi-disciplinary team.

Levels of the functional analysis

- Level 1: Task
  - represents the first stage wherein the client organisation perceives a problem
  - This problem may be realised through a study of efficiency, safety, markets, profitability etc.
- Level 2: Spaces
  - Represents the stage where the architect or the whole design team are engaged in the preaparation of the brief in conjunction with the client
- Level 3: Elements/Modules:
  - Is the stage where the building assumes a structural form
- Level 4: Components:
  - Is the point where the elements/modules take an identity in terms of buit form.
  - Components are selected to satisfy the requirements in terms of surrounding and servicing space

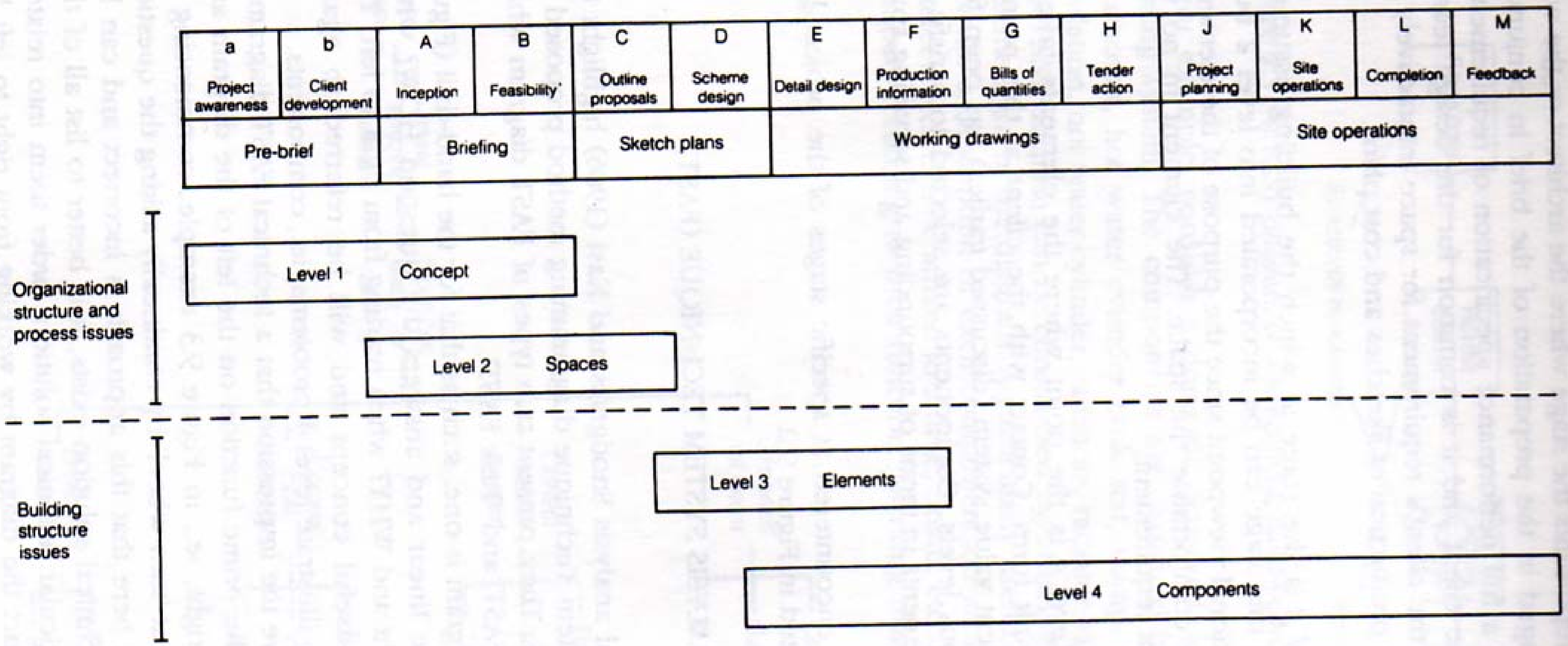
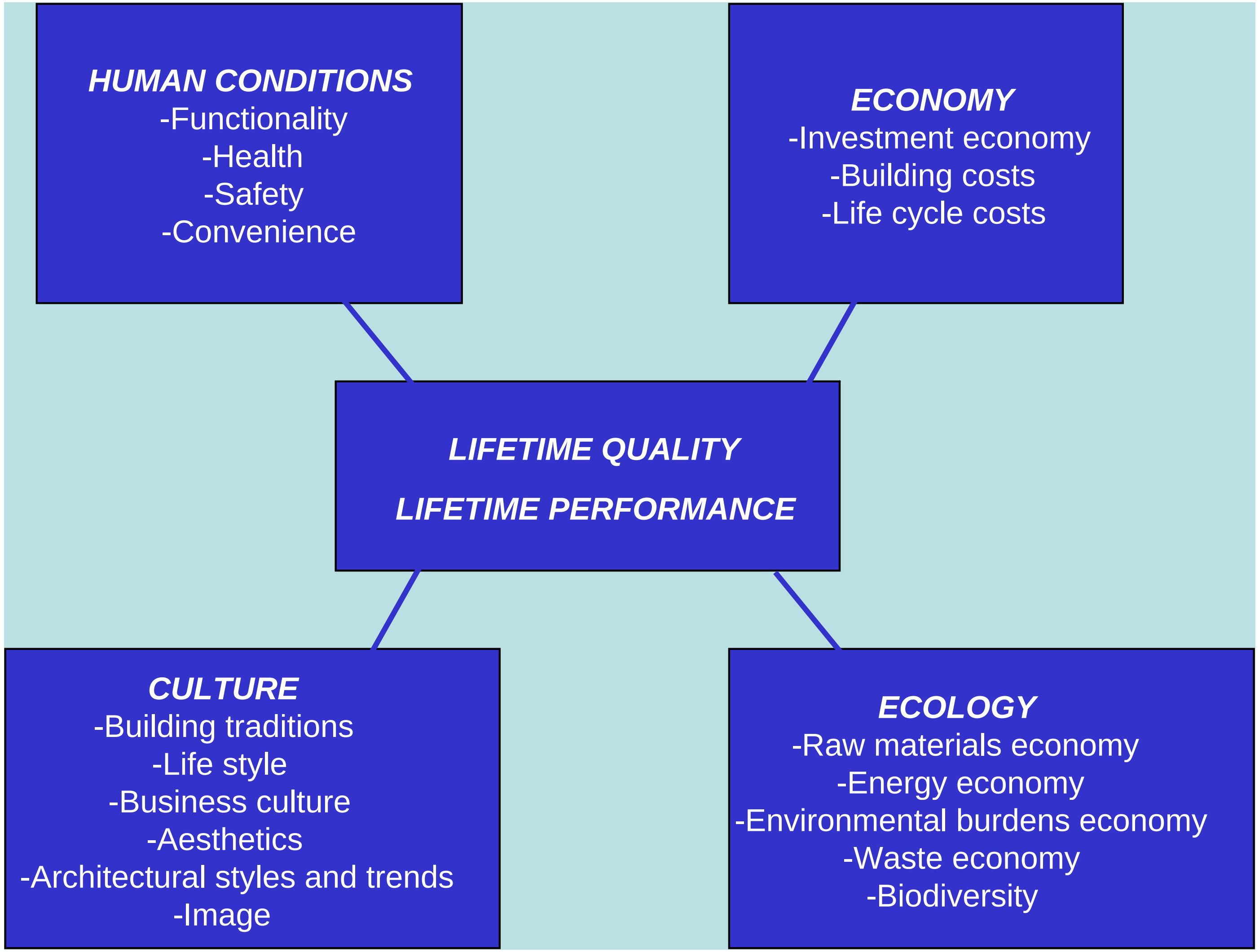


Figure 9.2 The level of decision encountered in the project life cycle.

[John Kelly and Steven Male, Value Management in Design and Construction. E&FN SPON London. 1993.]

CRITERIA OF LIFETIME QUALITY

of sustainable building



COMPONENTS OF LIFE CYCLE QUALITY

- Life cycle monetary cost (LCMC)
  - Construction cost (40-60% of LCMC)
  - Costs during the period of use (50 y: 60-40% of LCMC)
    - **Maintenance cost during design service life**
    - **Repair costs during design service life**
    - **Changing costs during design service life**
    - **Renewal costs during design service life**
    - **Energy cost during design service life**
      - **Recovery + Reuse**
      - **Recycling**
      - **Disposal**

COMPONENTS OF LIFE CYCLE QUALITY

- Life cycle functionality (LCF)
  - Functionality for the first user
  - Flexibility for changes of building services
    - **Flexibility for changes of spaces**
    - **Flexibility for changes in performance of structures**

COMPONENTS OF LIFE CYCLE QUALITY

- **Life cycle maintainability**
- Reliability in operation in normal and abnormal conditions
    - **Ease**
    - **Frequency**
    - **Staff requirements**

COMPONENTS OF LIFE CYCLE QUALITY

- **Environmental effectiveness of the life cycle(LCEC)**
  - **Consumption of energy in use (heating+lighting) - a dictating factor (ca. 90%)**
  - **Consumption of energy in production (ca. 10%)**
    - **Consumption of raw materials: Renewal/non-renewal**
    - **Production of pollutants and disposals into air, soil and water**

ENERGY ECOMY CLASSIFICATION

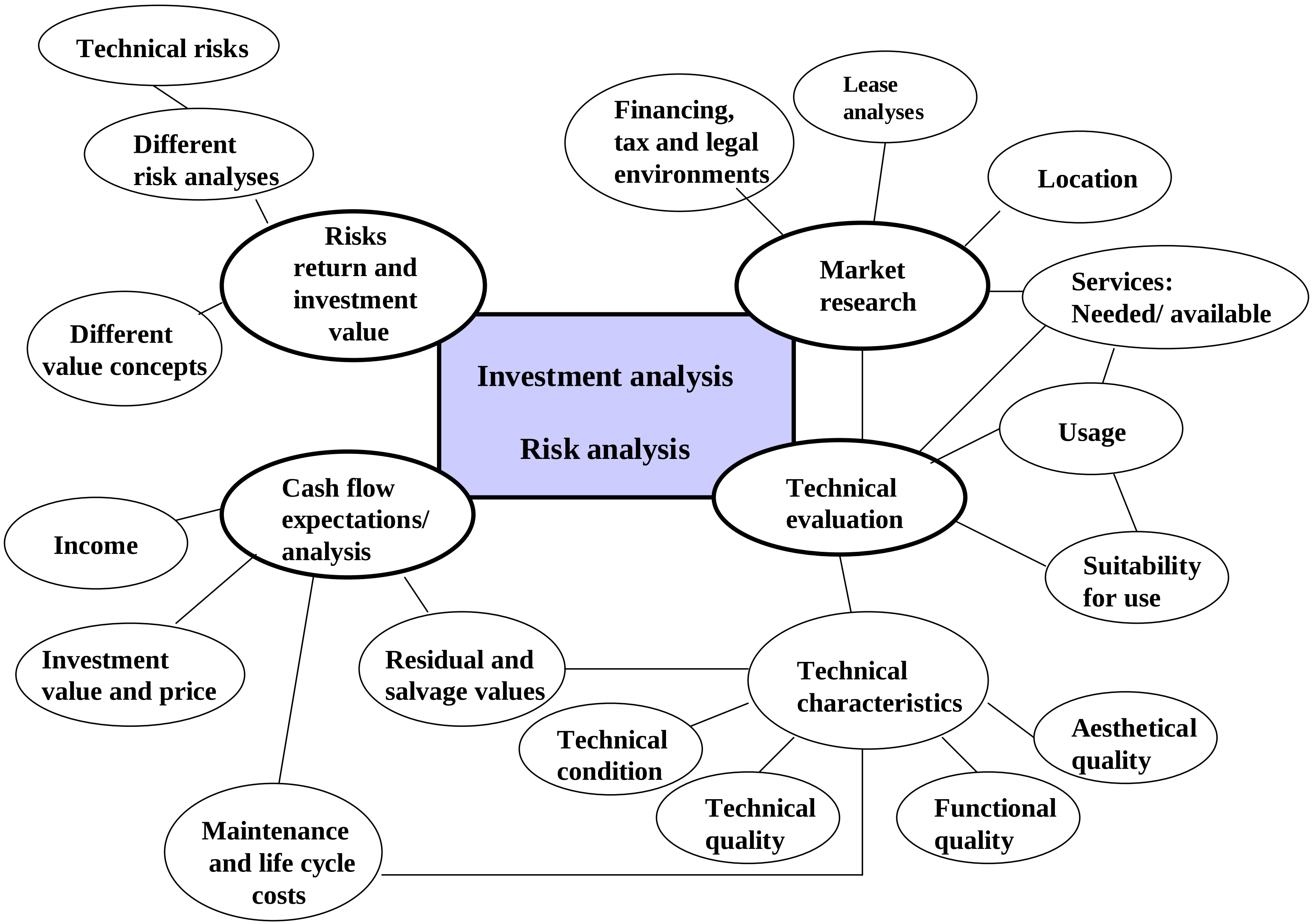
- Class 1. Standard level. Heating + cooling energy economy is fitting the current standards of each country or region .
- Class 2. Reduced energy level: less than 50% of the current level.
- Class 3. Low energy level: less than 25% of the standard level.
- Class 4. Zero energy level: Heating + cooling energy consumption is zero.
- Class 5. Plus energy building: the gain of solar or other natural energy is more than needed for heating and building service systems

COMPONENTS OF LIFE CYCLE QUALITY

- Safety, health and comfort
  - Internal air quality (emissions, fungi)
    - **Acoustic and visual privacy and convenience**
    - **Hygrothermal quality of internal conditions**
    - **Visual quality and aesthetics**
  - Working conditions during construction

PHASES OF THE LIFETIME ENGINEERING

- Lifetime investment planning
- Integrated lifetime design
- Integrated lifetime procurement and construction
- Integrated lifetime management and maintenance planning
- Rehabilitation and modernisation
- End-of Life Management:
  - Recovery, Reuse
  - Recycling and
  - Disposal

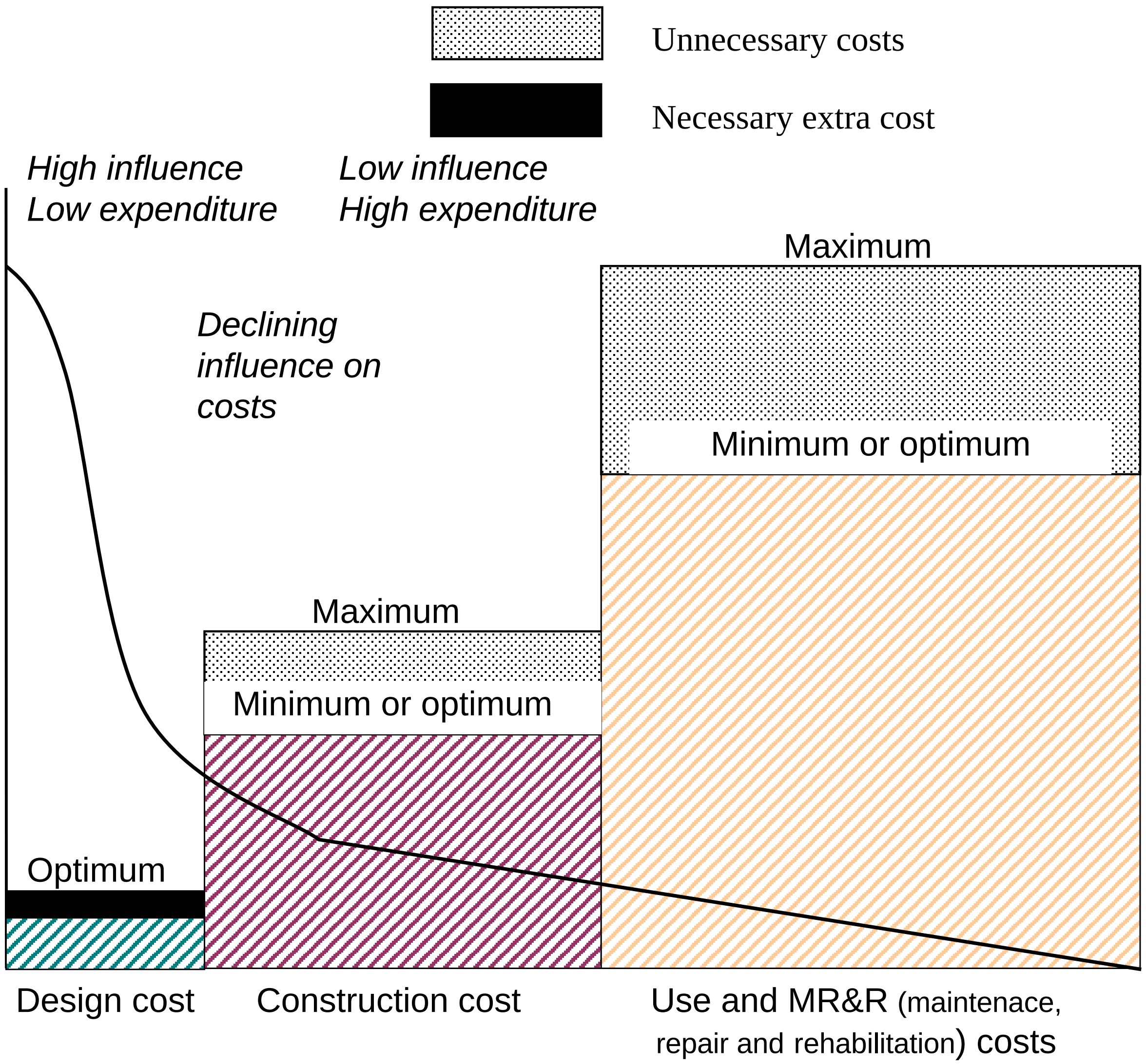


[Taina Koskelo,A METHOD FOR STRATEGIC TECHNICAL LIFE CYCLE MANAGEMENT OF REAL ESTATES]

Lifetime investment planning and decision making

- The investment planning and decision making applies value management to audit and optimise:
  1. The client`s use of a facility in relation to its corporate strategy
  2. The project brief
  3. The emerging design
  4. The production method

Potential Benefits during lifetime



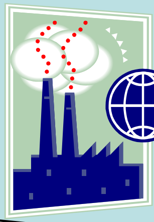
Modified from:
John Kelly and Steven Male, Value Management in Design and Construction. E&FN SPON London. 1993.

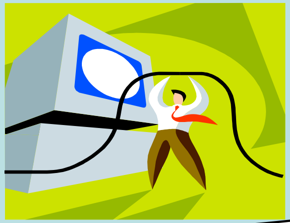
CENTRAL CONTENT OF ILC (integrated Life Cycle)-DESIGN

- Introducing the requirements of owners, users and society (environment incl.) into functional and technical specifications of materials and structures
- Modular service life planning and optimisation
- Performance based design of materials and structures, incl. service life design (durability)
- Design for reuse of components and for recycling of materials

INTRODUCING GENERIC CRITERIA INTO DESIGN

Sustainable Society - Sustainable Building





Generic Requirements for sustainable building

Generalised lifetime limit state design

Resistance against mechanical loads

Durability against degradation

Usability against obsolescence

Normative and traditional reliability theory and methods for structural design

FRAMEWORK OF ILC-DESIGN

Planning and Design phases, tasks and methods of integrated life cycle design.

LIFETIME PERFORMAMNCE AND COST MANAGEMENT - LIFETIME VALUE MANAGEMENT

Design phase	Lifetime Design Methods
1. Investment planning	Multiple criteria analysis, optimisation and decision making (MADA) Life cycle (monetary and natural) economy (LCC)
2. Analysis of client`s and user`s needs	Modular design methodology (MDM) Quality Function Deployment Method (QFD)
3. Functional specifications of the buildings	Modular design methodology. Quality Function Deployment Method (QFD)
4. Technical performance specifications	Modular design methodology. Quality Function Deployment Method (QFD)
5. Creation and sketching of alternative structural solutions	Modular design methodology. (MDM)
6. Modular life cycle planning and service life optimisation of each alternative	Modular design methodology. (MDM) Modular service life planning. Life cycle economy (monetary economy LCC and natural economy LCE) calculations.
7. Multiple criteria ranking and selection between alternative solutions and products	Modular design methodology. MDM Quality Function Deployment Method (QFD). Multiple Criteria Analysis, optimisation and decision making (MADA)
8. Detailed design of the selected solution	Design for future changes Design for durability Design for health Design for safety Design for hygro-thermal performance. User`s manual. Design for reuse and recycling

INTEGRATED LIFE CYCLE DESIGN PROCESS AND METHODS

- **1. Investment planning**
  - Multiple criteria analysis, optimisation and decision making.
  - Life cycle (monetary and natural) economy
- **2. Analysis of client`s and user`s needs**
  - Modular design methodology.
  - Quality Function Deployment Method (QFD)
- **3. Functional specifications of the buildings**
  - Modular design methodology.
  - Quality Function Deployment Method (QFD)

INTEGRATED LIFE CYCLE DESIGN PROCESS AND METHODS

- **4. Technical performance specifications**
  - Modular design methodology.
  - Quality Function Deployment Method (QFD)
- **5. Creation and sketching of alternative structural solutions**
  - Modular design methodology.

INTEGRATED LIFE CYCLE DESIGN PROCESS AND METHODS

- **6. Modular life cycle planning and service life optimisation of each alternative**
  - Modular design methodology.
  - Modular service life planning.
  - Life cycle (monetary and natural) economy calculations.
- **7. Multiple criteria ranking and selection between alternative solutions and products**
  - Modular design methodology.
  - Quality Function Deployment Method (QFD).
  - Multiple Criteria Analysis, optimisation and decision making

INTEGRATED LIFE CYCLE DESIGN PROCESS AND METHODS

- **8. Detailed design of the selected solution**
  – Design for future changes
  – Design for durability
  – Design for health
  – Design for safety
  – Design for hygrothermal performance.
  – User`s manual.
  – Design for re-use and recycling

MODULAR ILC-DESIGN

- **The tasks for each design alternative are the following:**
    - Classification of building modules into design service life classes, following a suited modular classification system.
    - Stating the number of renewals of each module during the design service life of the building.
    - Calculation of total life cycle monetary costs and costs of the nature (ecology) during the design life cycle of the building.
    - Preliminary optimisation of the total life cycle cost varying the value of service life of key modules in each alternative between the allowed values.

Specification of performance properties for the alternative structural solutions as an example a multi-storey apartment building.

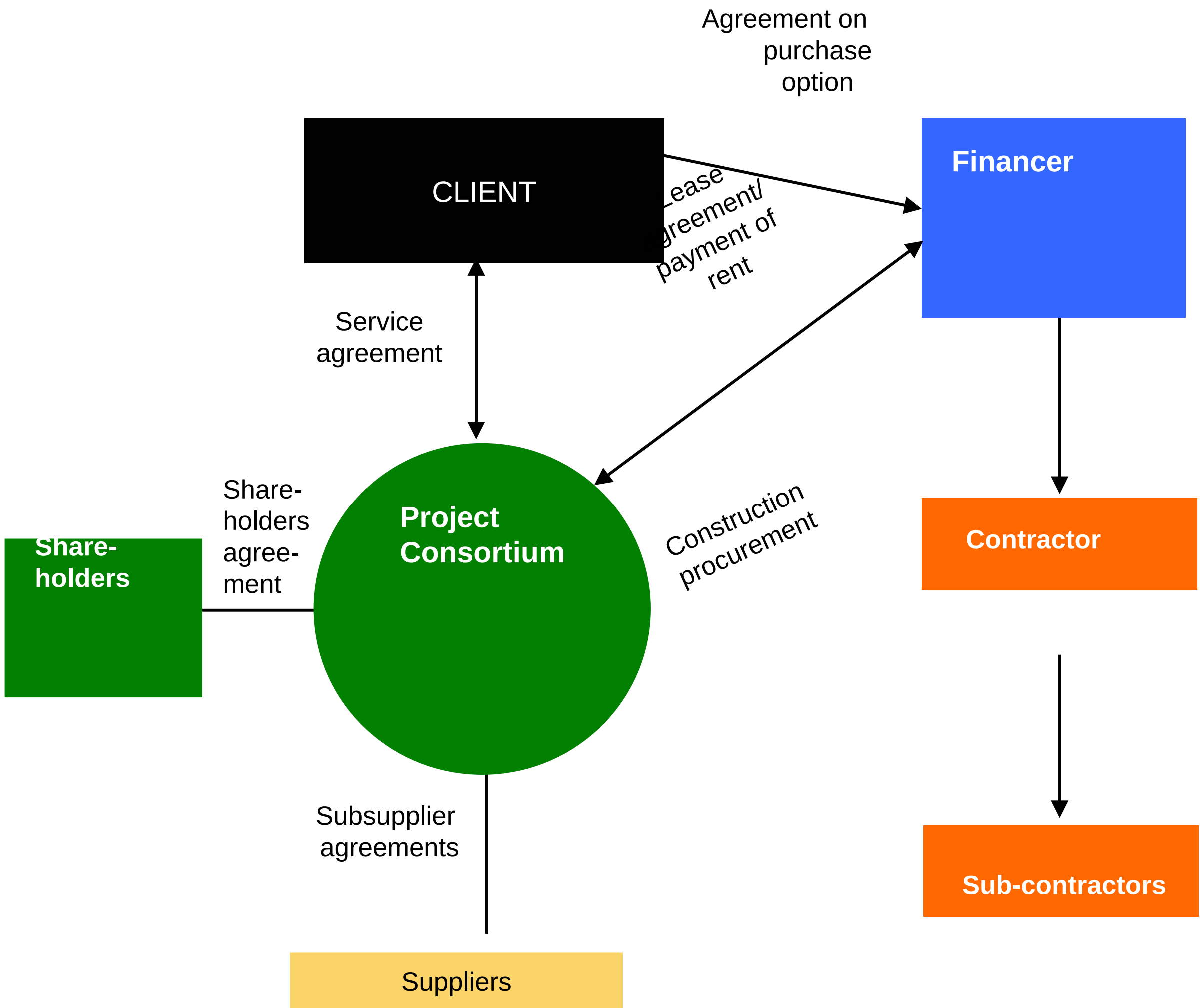
Structural module	Central performance properties in specifications
1. Foundations	•Bearing capacity, •target service life, • limits and targets of environmental impact profiles
2. Bearing frame	•Bearing capacity, •target service life, •estimated repair intervals, •estimated maintenance costs, • limits and targets of environmental impact profiles.
3. Envelop/Walls	•Target values of thermal insulation, •target service life, •estimated repair intervals, •estimated maintenance costs, •limits and targets of environmental impact profiles
4. Envelop/Roof	•Target values of thermal insulation, •target service life, •estimated repair intervals, •estimated maintenance costs, •limits and targets of environmental impact profiles
5. Envelop/Ground Floor	•Target values of thermal insulation, •target service life, •estimated repair intervals, •estimated maintenance costs, •limits and targets of environmental impact profiles

6. Envelop/Windows	**• Target values of thermal insulation, • target service life, • estimated repair intervals, • estimated maintenance costs, • limits and targets of environmental impact profiles**
7. Envelop/Doors	**• Target values of thermal insulation, • target service life, • estimated repair intervals, • estimated maintenance costs, • limits and targets of environmental impact profiles**
8. Partition Floors	**• Target values of sound insulation, • target service life, • estimated repair intervals, • estimated maintenance costs, • limits and targets of environmental impact profiles, • estimated intervals of the renewal of connected installations**
9. Partition walls (incl. doors)	**•Target values of sound insulation, • target service life, • estimated intervals of spatial changes in the building, • estimated repair intervals, • estimated maintenance costs, • limits and targets of environmental impact profiles, • estimated intervals of the renewal of connected installations**
10. Bathroom and kitchen	**• Target values of sound and moisture insulation, • target service life, • estimated repair intervals, • estimated maintenance costs, • limits and targets of environmental impact profiles, • estimated intervals of the renewal of connected installations**

CRITERIA IN SELECTION BETWEEN ALTERNATIVES

- **The selected alternative can fulfil some of the following criteria:**
  - Best in all requirements
  - Best weighted properties on reasonable cost level
  - Best in preferred requirements, fulfilling accepted level in all requirements
  - Best in valuated multiple criteria benefit/cost ratio

LIFETIME RESPONSIBILITY PROCUREMENT

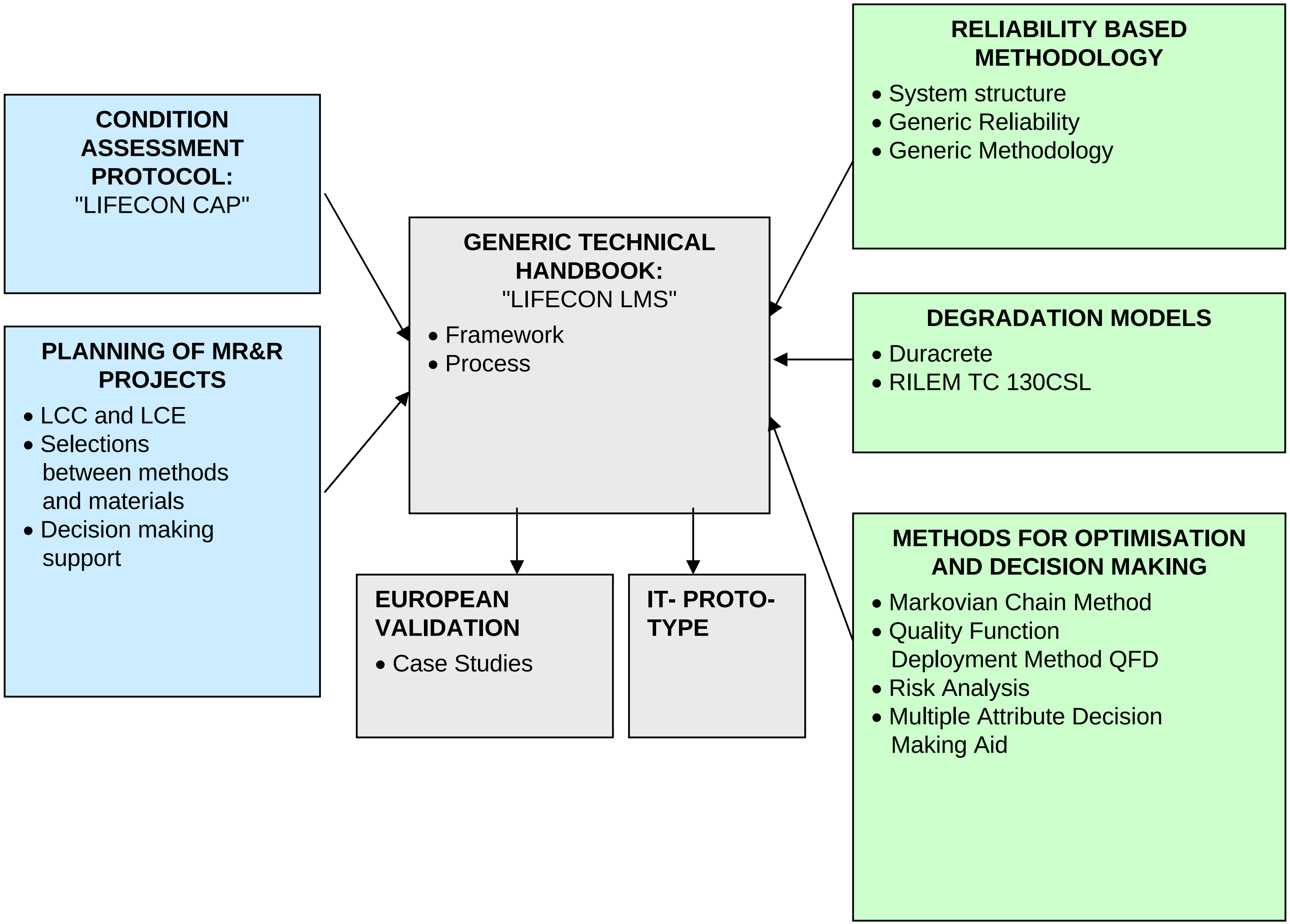


Lifetime Responsibility Procurement (Lifetime Contracting)

[Dr. Hywel Davies, Review of Standards and associated literature on technology and lifetime economy]

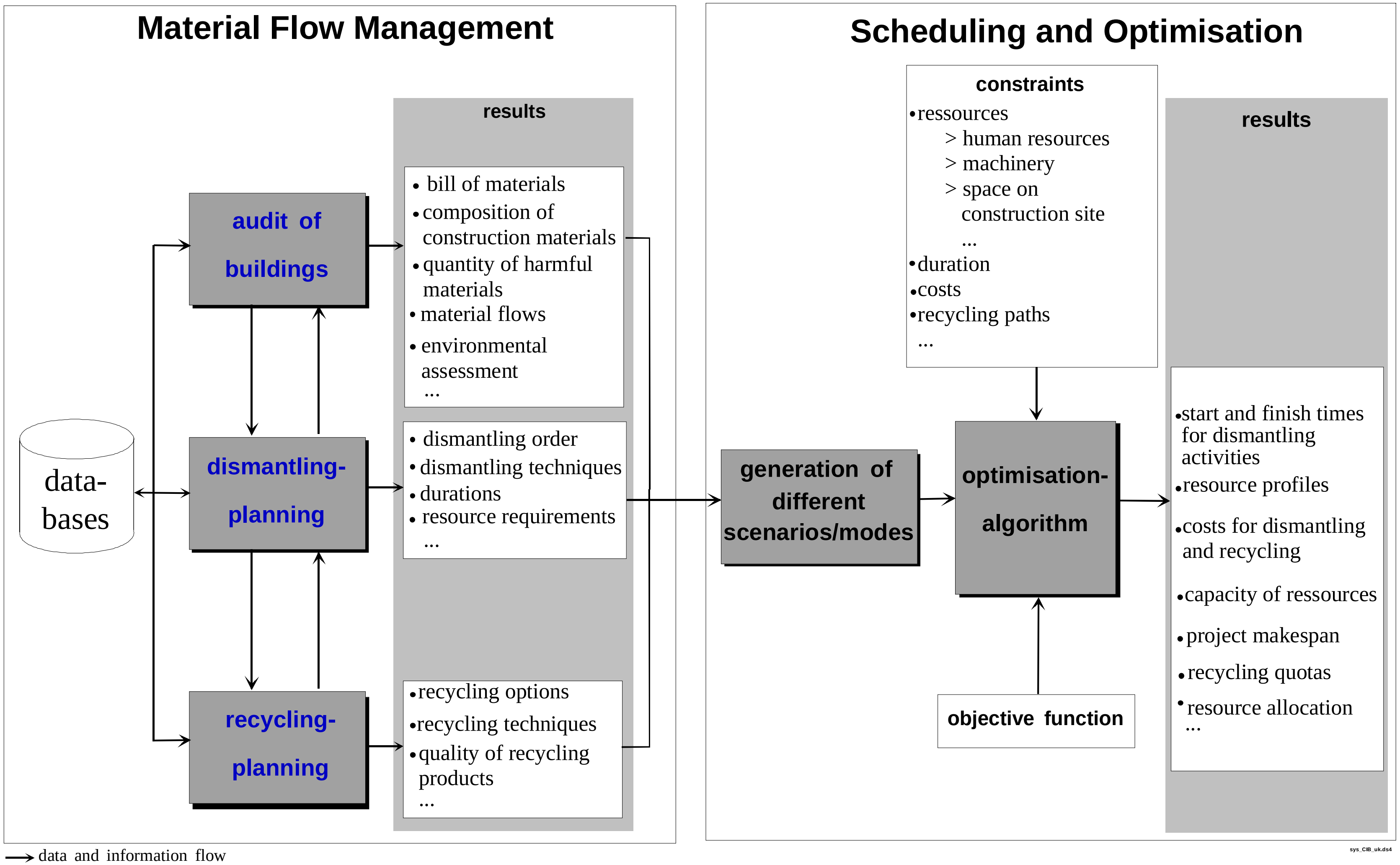
- **Innovations in public sector:**
  - **Private Finance Initiative (PFI) and**
  - **Public Private Partnership (PPP).**
- **PFI/PPP are efficient and effective ways of delivering services to the public sector**
  - **the responsible contractor has real interest in optimised lifetime costs and**
  - **the client defines the requirements and criteria for lifetime quality**
  - **is applied both in building and civil engineering sector**
  - **usual contract time period 20 - 25 years**
  - **Variations of Lifetime Contract process:**
    - **“Design, Build and Operate” (DBO),**
    - **“Design, Build, Finance and Operate” (DBFO),**
    - **“Build, Own, Operate, Transfer” (BOOT)**

Predictive and optimising Facility Management



End-of Life Management

[Prof. Dr. Frank Schultmann, **End-of-Life Management of Buildings**, **Chair for Construction Management and Economics, University of Siegen**]



Working environment of Lifetime Engineering