LECTURE

6 Systems engineering tasks

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LECTURE 6 - OVERVIEW

Structure of systems engineering tasks

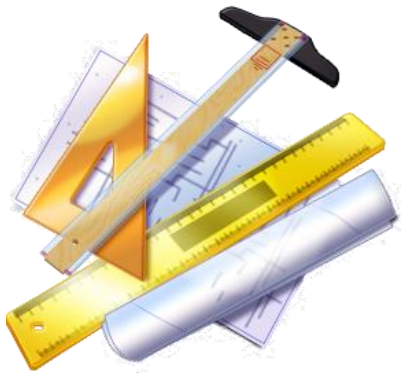
Standard system engineering tasks

Selected system engineering tasks

Task of system control

SYSTEMS ENGINEERING TASKS PREMISES

- They are working with systems – the goal is the analysis, synthesis and evaluation
- The engineering characteristics of measurability, algorithm development, demonstrability, organization, effectiveness are respected (they are engineering tasks, not intuitive, artistic, ...)
- They share basic tools and methodologies of systems analysis
- They have constructive background



STRUCTURE OF SYSTEMS ENGINEERING TASKS

combination of systems analysis and systems design

Basic types

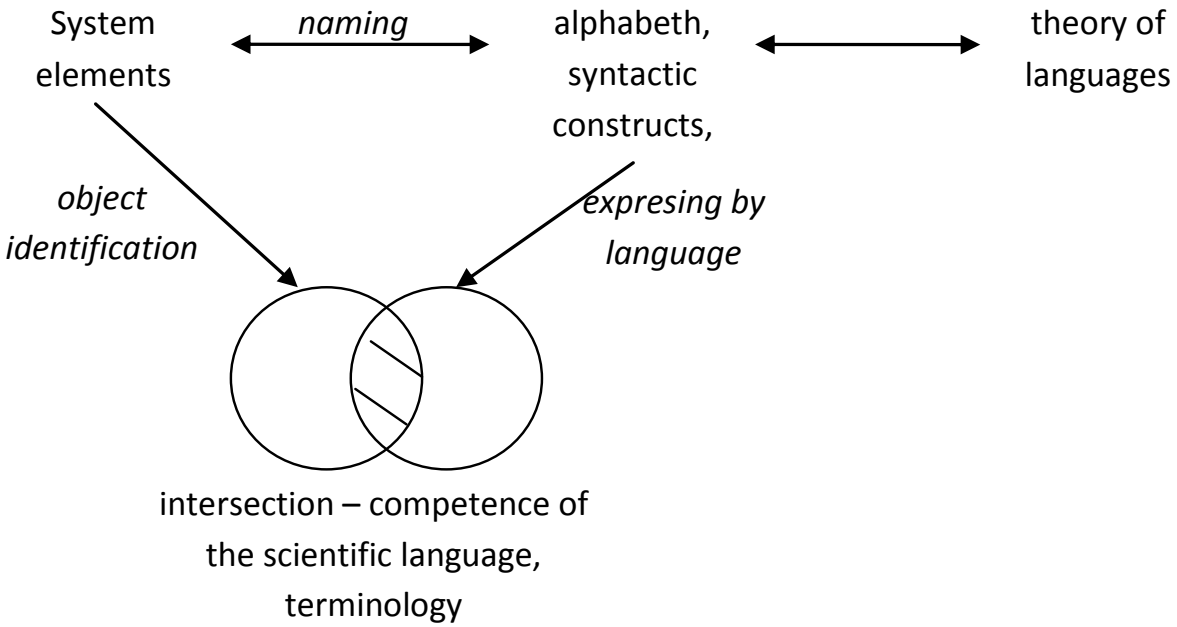
- constructional approach
  (tasks about construction, about attributes, about phenomena's forms)
- application approach
  (relation between model and original, control of the original)

- tasks of model creation (in the model)
  - construction of language,
  - construction of metrics
  - identity
- with a model (on the model)
  - About structure
    - interface,
    - paths
    - capacities,
    - clusters,
    - heterogeneity;
  - about dynamics
    - types of algorithms,
    - changes of a state space,
    - activating of processes;
  - about a development
    - targets,
    - competence,
    - contamination,
    - survival with a genetic code,
    - artificial intelligence
- controlling (about the model)
  - control
  - design
  - strategy

STANDARD TASKS OF SYSTEMS ENGINEERING

1. construction of language

choice of suitable alphabet enables isomorphism of the model and system elements, their relation (grammar) and semantics



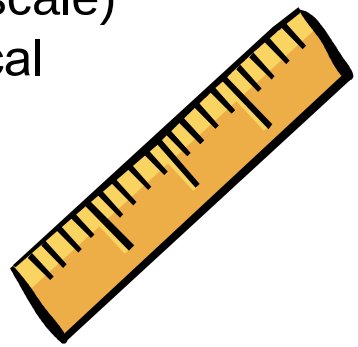
STANDARD TASKS OF SYSTEMS ENGINEERING

2. metrics of system and scaling

Enables system components to be described by measurable and comparable values

Scales:

- *absolute* - identity of an element with an comparable element, no sense to introduces any scale
- *cardinal*- an ordered scale with arithmetic operations
- *interval* - a more sophisticated index, instead a hard distance between elements of the scale there are ordered intervals (a soft affiliation of an evaluated element to an element of scale)
- *ordinal* - it hasn't any sense to process an arithmetical operations, for example an alphabetical order
- *nominal* - a list of elements
- Axiological – distance from standard



STANDARD SYSTEMS ENGINEERING TASKS

3. Interface tasks: significance is that this task *guarantees the integrity* of system parts --> regularity of relationships --> solving of relevant irregularities

4. Path tasks: paths in graphs are *images of processes*, utilization of theory of graphs tools

5. Capacity tasks: capacities are hidden in an organization, goal is to seize the necessary capacity, then to balance the capacities (balancing the resources)

6. Cluster analysis tasks: a tool for solving multicriterial analysis using mathematical statistic

STANDARD SYSTEMS ENGINEERING TASKS

7. Tasks about dynamics:

System dynamics is very important parameter.

Introduces the time aspect (both absolute – e.g. calendar, and relative – mutual comparison, sequence of events, etc.)

time dependence

- short time
- middle
- long time

STANDARD SYSTEMS ENGINEERING TASKS

7. Tasks about dynamics:

- Tasks about function states changes can be modelled e.g. by Petri nets
- State space changes tasks
  - in values, that is conservation x development x recession
  - in structure, that is homeostat x conversion
- Changes in species - development, that is maintenance x mutation x accident x catastrophe
- Changes in combination of species, that is selection x splitting x transmission x hybridization

8. activation of processes

a promptness of system in a response to an external event (theory of signal functions with 1., 2. and 1,5. level)

Conditions for activation

SELECTED TASKS OF SYSTEMS ENGINEERING

These tasks form the basics of Systems engineering and represent its benefits

I. identity of system

identity = attribute of **every** object, **(see lecture 2)**

Relation of the system and its surroundings

Two types of tasks:

- Constructin of identity
- Control of identity, dynamics of identity

IDENTITY DYNAMIC TASK - EXTERNAL

- management of identity's changes

Inputs are in the surroundings of the system

for an external identity's coefficients

- Task of increasing the goal processes important for the super-system – enlarging the competence of system

Resulting in:

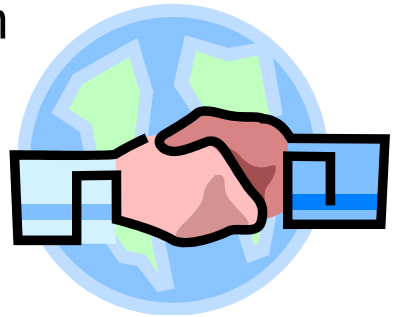
- maximal values of partial coefficients mean increasing of system's specialization
- that is also reduction of M (magnitude) – number of unnecessary processes (but it is a danger for adaptability or reliability of the system!)

IDENTITY DYNAMIC TASK - INTERNAL

internal identity improvements:

- Goal to lower differences between partial coefficients → increasing number of cooperating processes
- Usually done by extension of element's functions either by one-sided or two-sided adaptation (see interface tasks)
- another possibility is a forced cooperation or a motivation approach for a cooperation between parts

- Decreasing the difference between the number of all processes and cooperating processes has close relation with the survival of the system



SYSTEM TASKS - HETEROGENEITY

heterogeneity of system - rate of disparity of parts

Related to the interface task – by regularizing the interface the homogeneity of system is supported

homogenisation of structure is done by interface task --> a reciprocal "understanding" → tasks about translatability:

Important role - translatability

- semantic - it is task about mutual comprehension between system's parts
- axiomatic - either non-empty intersection between competences, or rules for relationships between pairs of languages
- epistemic - possibility of communication can affect an ability of survival
- pragmatic - translatability decides about rate of cooperation
- with an engineering approach - resolvability of translatability with goal to manage this translatability

SYSTEM TASKS - TRANSLATABILITY

1. Translatability task:

Task:

Language construct S written in alphabet N to be translated into language T

Finding the rules p (derivative rules) to translate the language construct

understanding – incomplete, inexact, but possible translatability-> an allowable degradation of a translatability either in an orientation (a transfer between languages) or in a quality (a competence or a superiority of languages)

derivative, inference rules --> utilization of cluster analysis methods with a similarity of two languages and their grammars

SYSTEM TASKS - DYNAMICS

2. Dynamics of goals achieving

three types of dynamic goals:

- *Maintenance of values* of state space → proves the existence of the system
- Resulting values → goal behaviour, results of transformation functions
- Acceptance by surroundings → identity, ethics of a system

State space can be:

- *conservative*
- *development*
- *decrement*

in quality it is possible to recognize:

- *importance of linkage – importance of growth, development* (revolutionary changes or evolutionary development)
- *completeness of linking* (transition or change in time, transformation of inputs to outputs)
- *motive of linking – metabolic, creative, etc.*

SYSTEM TASKS - COMPETENCE

3. Competence tasks

competence as a relationship between system and its surroundings, value of non-empty intersection of the system and its surroundings where the system applies its competence

Competence tasks:

- calculating of the non-empty intersection
- analysis of the form, structure of competence
- ensuring of conditions for the competence
- goals (orientation) of the competence (a hierarchy)

SYSTEM TASKS - CONTAMINATION

Contamination tasks

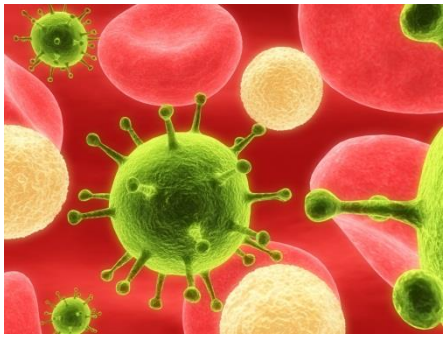
possible explanation of „contamination“:

- from dictionary → mixing, etc.
- pragmatically → infection
- practically → results of fusions etc.
- theoretically → work with genetic algorithms, hybridizing
- for engineering → algorithms and methods how to detect, analyze

SYSTEM TASKS - IMUNITY

a contamination is related with the immunity of system:

- *form of immunity* → intactness of system's parts or a conflict between contamination sources (mutual contradiction) or a generation of new functions in a system's structure
- *sources* of immunity
  - own – using internal supplies and reserves in functions
  - imported – that is loans, supports etc.
- *tasks about an immunity* → calculating:
  - place of an attack
  - paths of touched processes
  - structure of the immunity
  - changes of system's states by immunity's effects

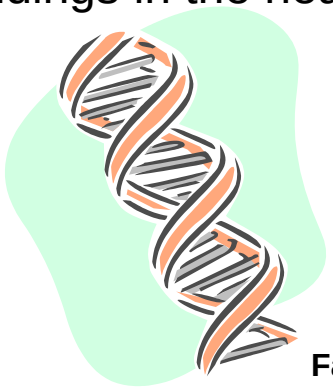


SYSTEM TASKS – GENETIC CODES

5. with genetic algorithms

requirement of portability of basic system's concept

- Finding interpretation of functions in internal presumptions (functions of genetic code) → dominant functions of genetic code:
  - introvert
    „strong" functions impact the others (using interface task)
  - extrovert
    genetic code influences surroundings of the system (interface task with the surroundings in the near neighbourhood)



SYSTEM TASKS – GENETIC CODES

- Tasks based on the number of participants
  - One: development of unique type of system → *maintenance* × *mutation* × *accident* × *catastrophe*
  - More than one: creation of new system that is a projection (combination) of least two types of systems → *selection* × *splitting* × *transfer* × *hybridization*
- Attraction
  - *function of an attractor* is possible only in space with a high level of entropy (similar to gravitation laws) → limiting condition in a possible change of mutual difference of systems - as a phenomena of a competence between them
  - *possible modes* of an attraction: singular × periodical × quasi-periodical × chaotic
  - *effect of an attractor*: missing × integration × mixing × liquidation
- Species evolution
- Inheritance
- ...

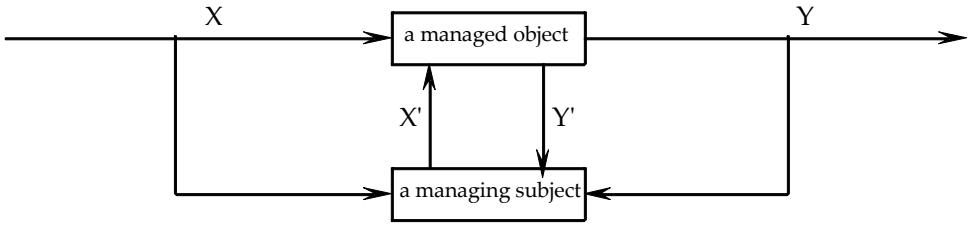
TASKS ABOUT A CONTROL OF SYSTEMS

Systems control = basic goal of system engineering

I. principles of a control

from the theory of automata

Basic control diagram



where X = external events

Y = answers of controlled object

X‘ = sources from controlling subject (targets of managing)

Y‘ = internal status of controlled object (a back relationship)

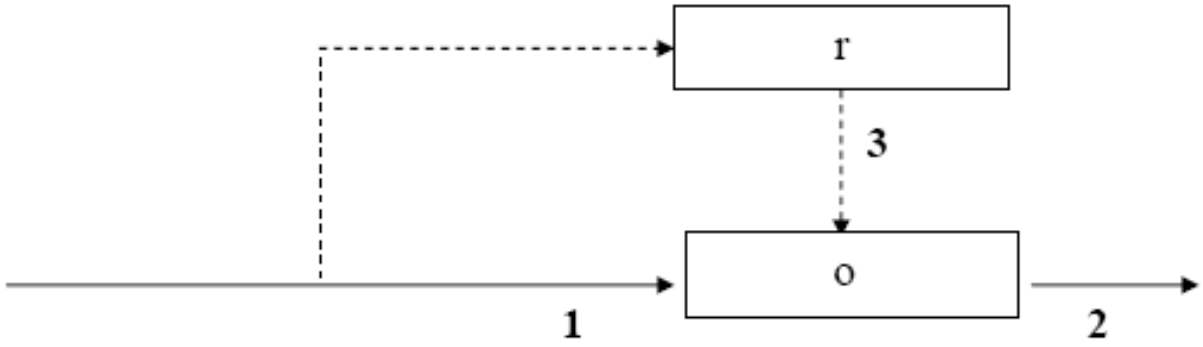
SYSTEM CONTROL

- memory functions
- Control types:
  - simple – by requirements (from a managing subject)
  - feedback control
  - adaptive (control is adapting by status of controlled object)
  - interactive (anything as a discussion between subject and object)
  - on the base from genetic code
  - with learning of managing
- self-organization (an integration of object and subject), an auto-regulation
- Control tools (base on creation of images of controlled objects objects and their status) → informatics → qualitative levels of information (data - information - knowledge...) → knowledge management

SIMPLE CONTROL (OPEN-LOOP CONTROLLER)

System does not have information about its outputs. There is no explicit feedback.

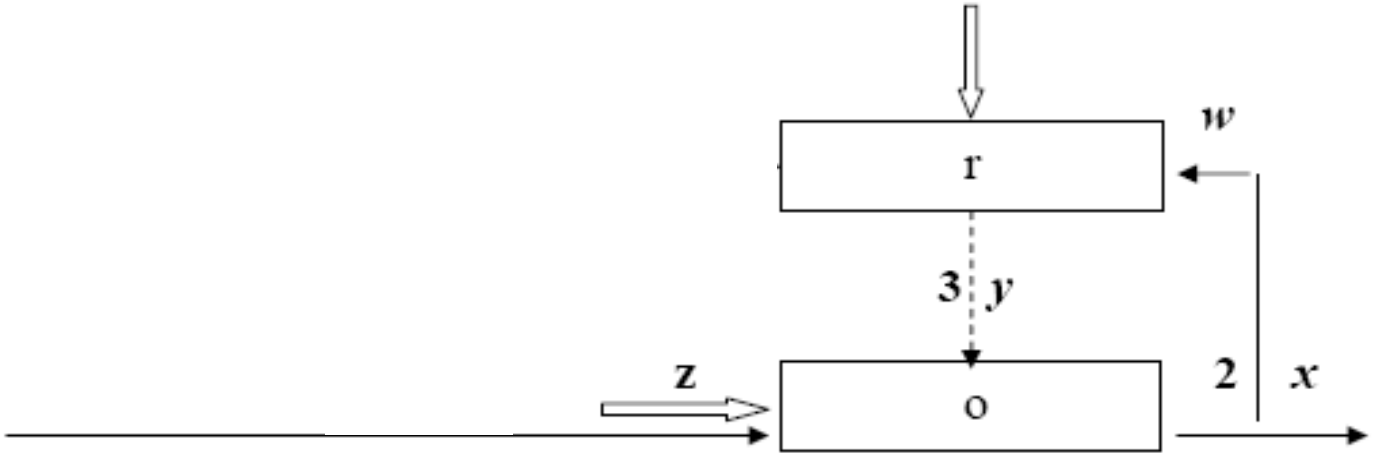
This type of control is used only when output is robust, safe – e.g. two state control (binary)



CONTROL ACCORDING VARIATION (FEEDBACK CONTROL)

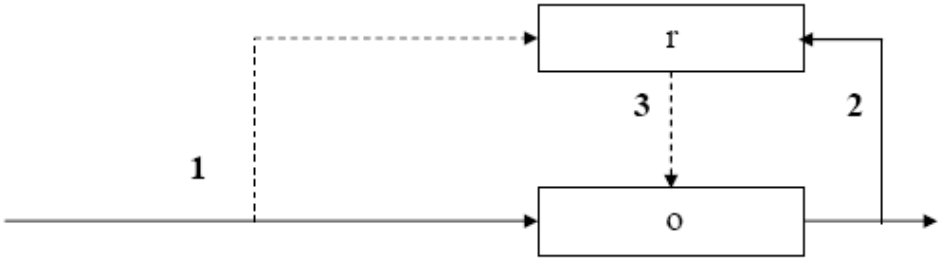
Basic and the simplest type of feedback control. The controller „r“ is influenced by output „2“ (with value „x“). Output value is compared to the actual reference value „w“. Depending on the variation (x – w) „r“ creates („r“ is also called the regulator) value y, transmitted on the control connection „3“ and influencing „o“.

Note: the reference value may change in time



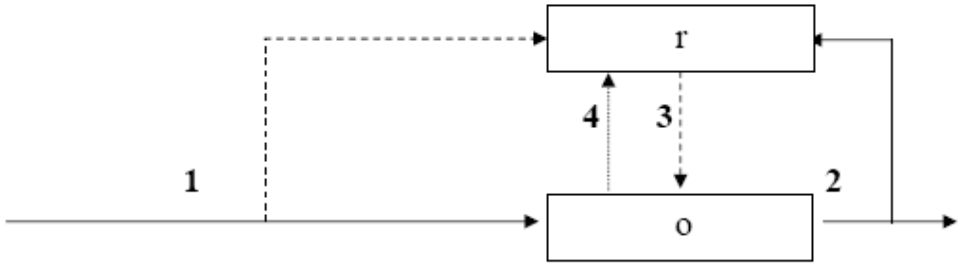
ADAPTIVE CONTROL

Unlike the simple feedback control function „r“ is **modified** using input „1“. This enables more accurate control



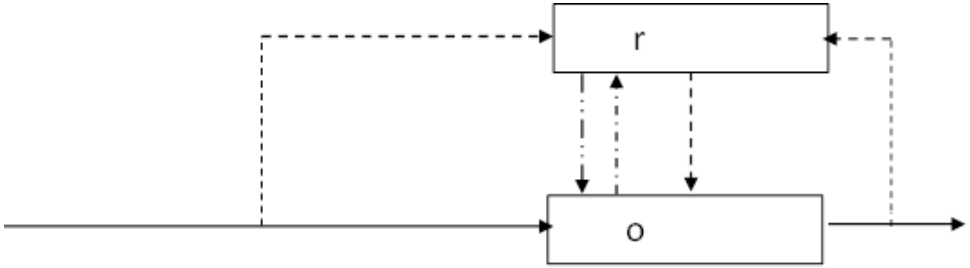
INTERACTIVE CONTROL

A new connection is added, the inner connection „4“. Using this connection „r“ gains information about current state „s“. This enables further improve qualitative, quantitative and dynamic parameters of the control.



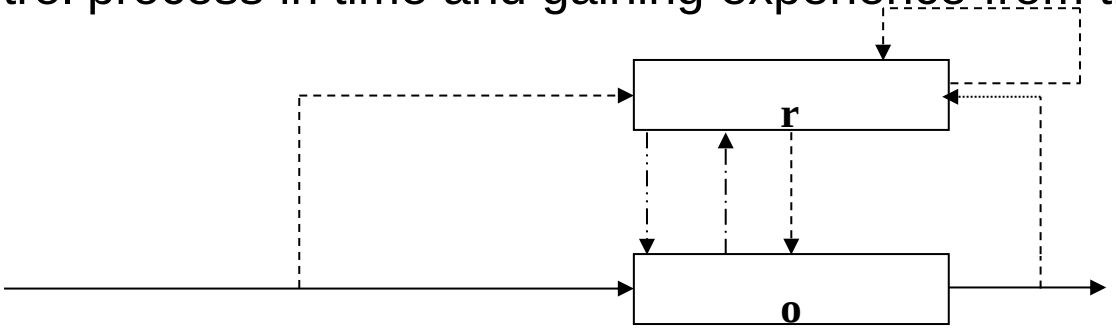
CONTROL WITH PREMISES (USING GENETIC CODE)

In the structure there is a new connection, which serves for control of the process distance from the genetic code.



CONTROL WITH LEARNING

In the structure we can additionally identify loop in the control subsystem „r“. This means (in the simplified form) the possibility of storing information about control process in time and gaining experience from this.



SYSTEM CONTROL

II. Space for system control

system approach is applied to:

- Controlled object
- Controlling subject
- Both

creating and utilization of image of controlled object with orientation to:

- *targets*, for example effect's orders
- *activation of sources* it means a participation of system's parts at an achievement of targets
- *phases of a creation of an image*, that is information or knowledge engineering
- *reliability of the image*, it means „a reduction" of an asymmetry (homomorphism) between managed and managing (a softness, a question of a translatability, a transfer of grammars etc.)

SYSTEM CONTROL

III. architecture of control tasks

in this case elements = partial control tasks,

Based on priorities of control tasks:

- designing → prefers metrics, changes of state space
- controlling → prefers goals
- regulation (operative management) → prefers values of contamination, (information, knowledge) capacity
- orientation on development (long-time strategies) → prefers competences, responsibility and hierarchy

SYSTEM CONTROL

IV. processes of system control

three function blocks of control:

- controlled object (1)
- control environment (2)
- controlling subject (3)

system control is formula Q = U(1, 2, 3)

types of control by emphasizing one of these blocks:

- developing, recognizing → emphasis on block (1)
- realistic → emphasis on block (2)
- power → emphasis on block (3)

SYSTEM CONTROL

V. Basic control tasks

Tasks about self-organization

- system must be opened to its surroundings, it must be able to communicate (external events are as a sources for managing)
- in its structure there does not exists balance – must be able to adapt (otherwise threatens disorganization…)
- in its surroundings exist stimuli, that is „reasons for changes“

SYSTEM CONTROL

Tasks of control system design

- Design methods
  - known top-down (specifying, decomposition...)
  - known down-up (catalogue elements, a composition...)
  - modular design from whole modules (problem with compatibility of these)
  - design with standards (with frame)
  - Layered methods: first layer - concept and goals, second layer - functional accessibility, third layer - technical realization
    Note: Recall the Systems analysis, Telematic systems and their design course,
    ITS architecture FRAME (user needs, functional, physical viewpoint)

SYSTEM CONTROL

- Design postulates
  - coherence (interface or compatibility)
  - disjoint parts
  - around the same scale of parts of a project and their synchronization
  - continuous control of possible goal of a project (possible change of targets)
- Compatibility of documentation
  - translatability of languages in a project (formulas, algorithms, non-completeness of translating etc.)
  - medium of documentation (a quality, an authorization, a responsibility)

SYSTEM CONTROL

Tasks about strategies

- topic of a strategy, concept of a strategy, real strategy
  → goals and orientation of strategy
- selected architecture of strategy
- system definition of strategy

Thank you for your attention

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