Introduction
Basics of CMMI
Project Management

VIMIMA11 Design and integration of embedded systems

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MŰEGYETEM 1782

Topics

Introduction

CMMI

Project planning

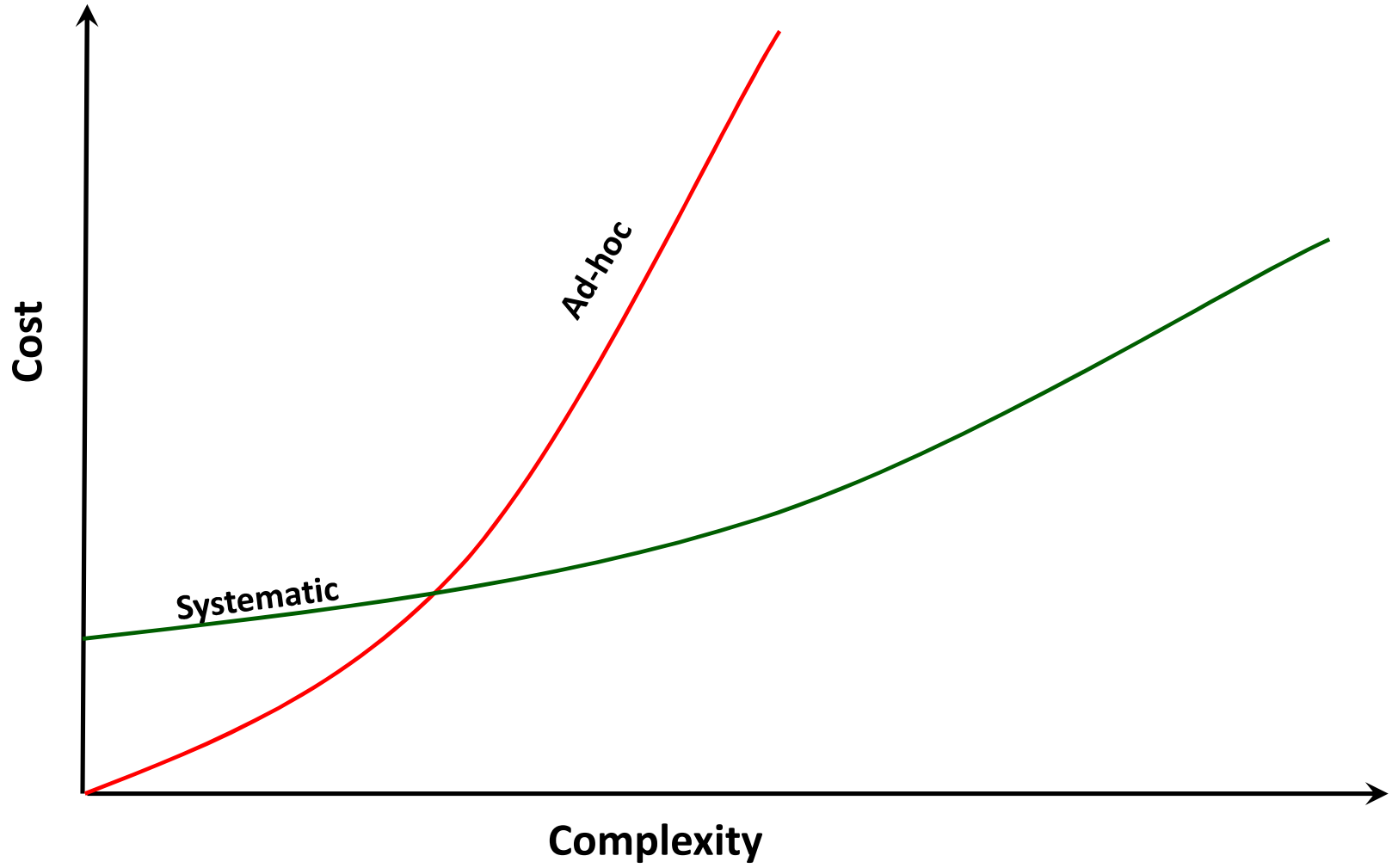
The Demand for System Designing

Introduction

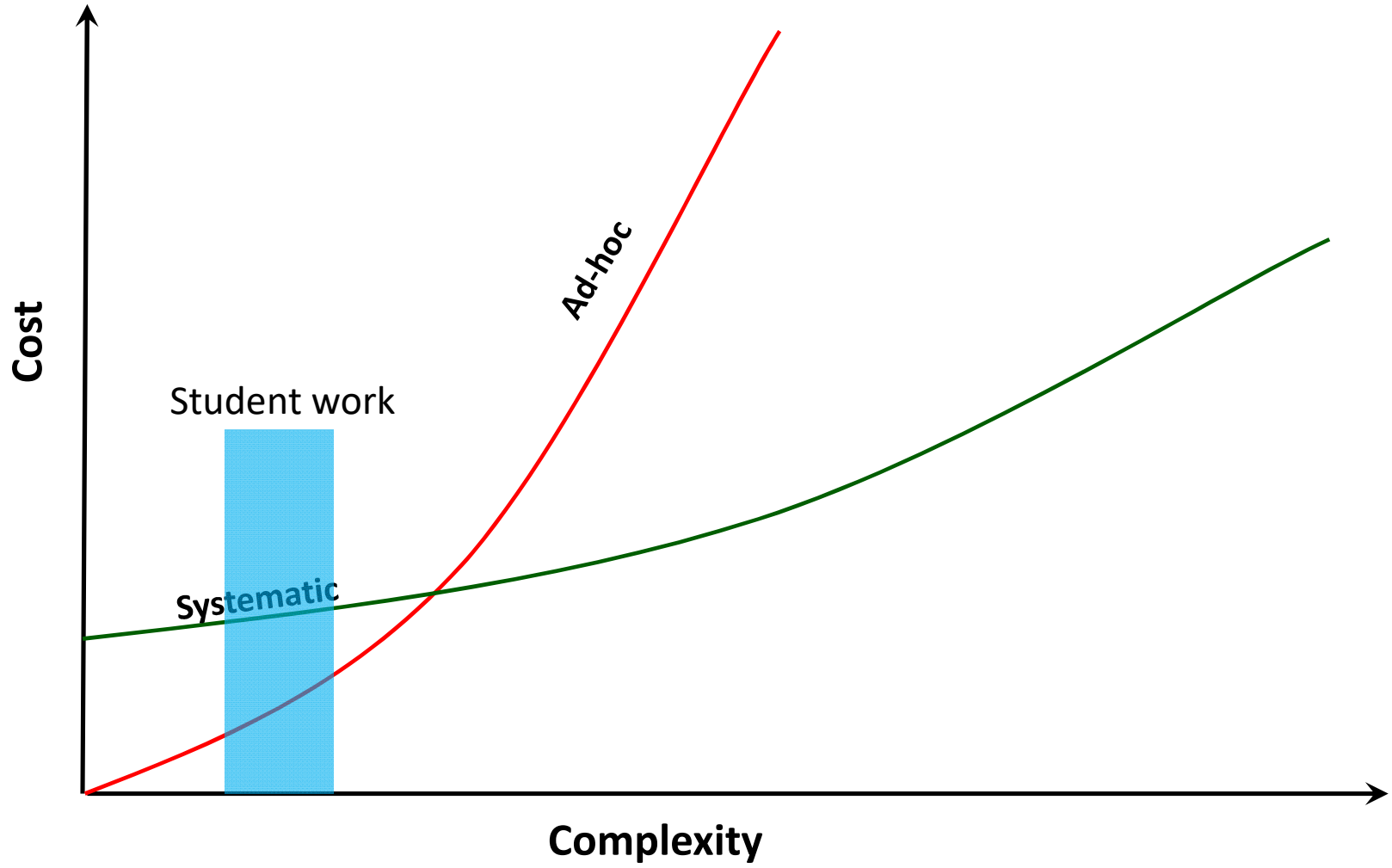
CMMI

Project planning

Ad-hoc vs. Systematic Development

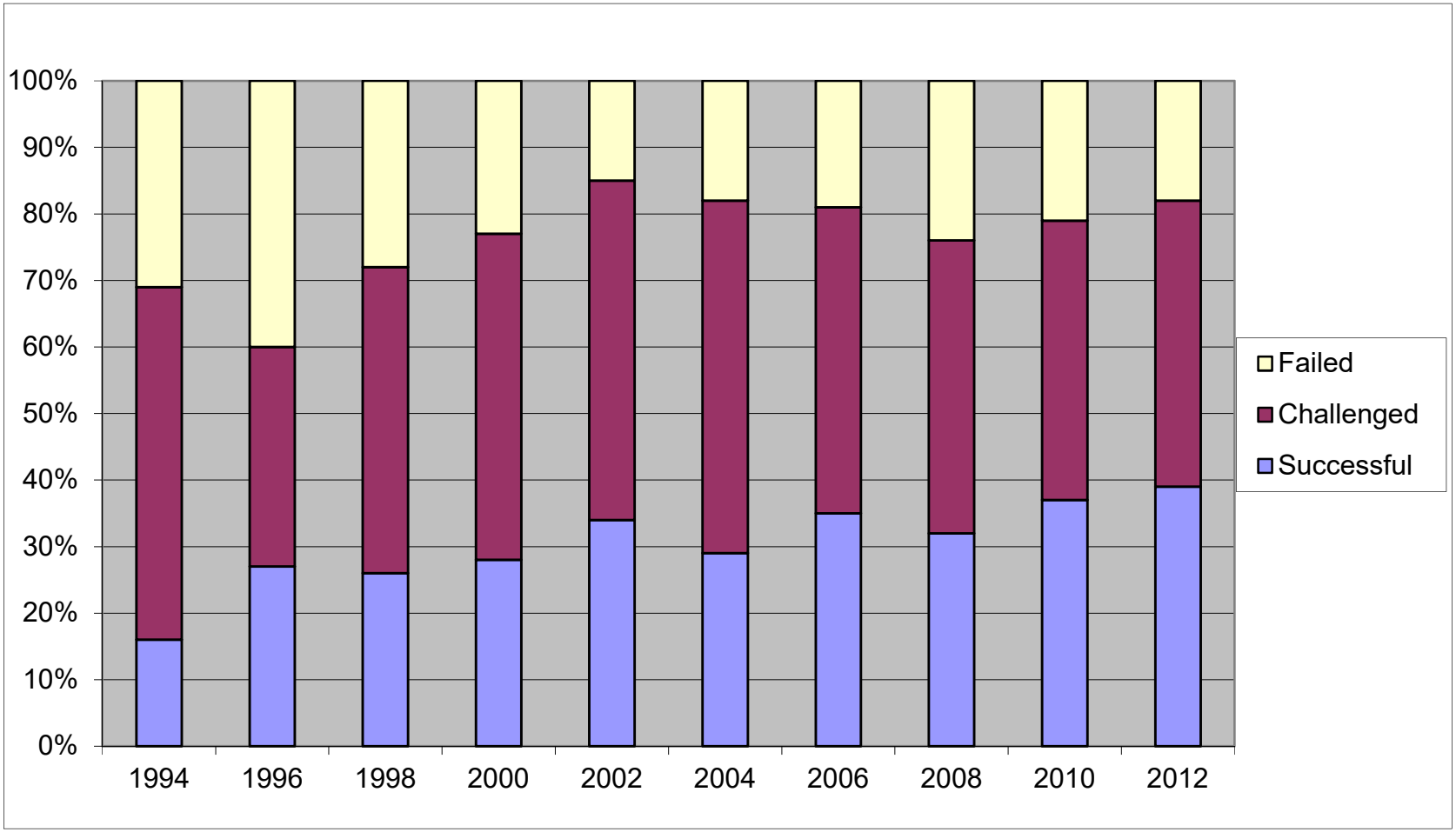


Ad-hoc vs. Systematic Development



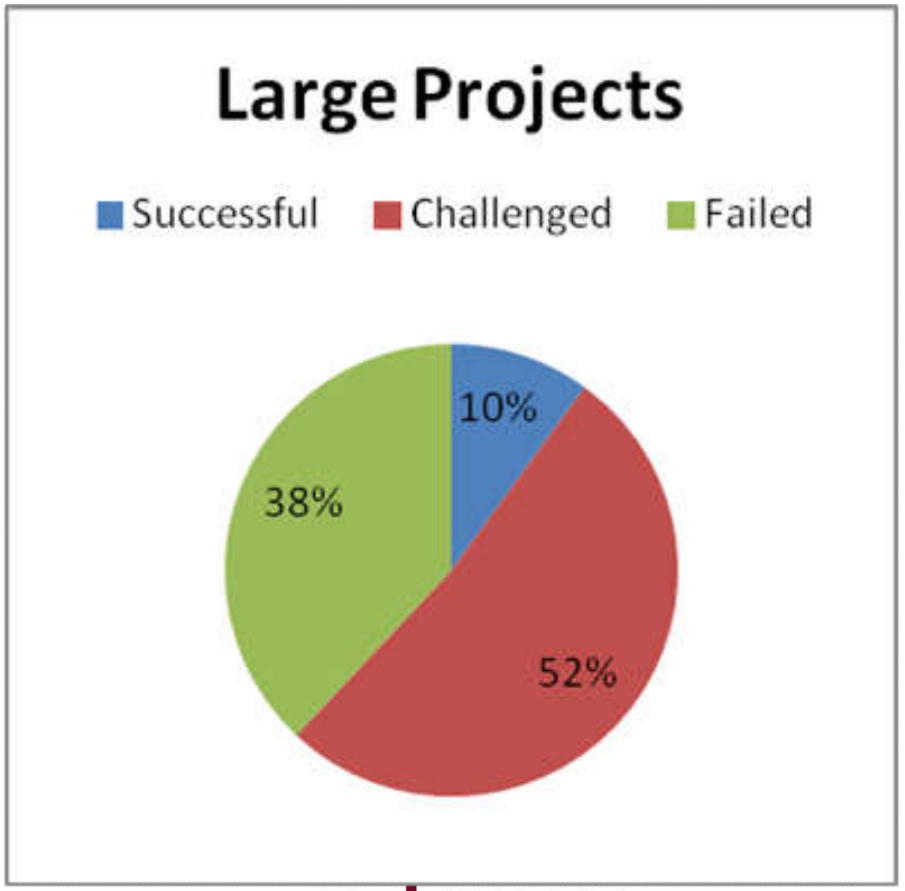
Project Success rate statistics

- Standish Group CHAOS report (software projects)



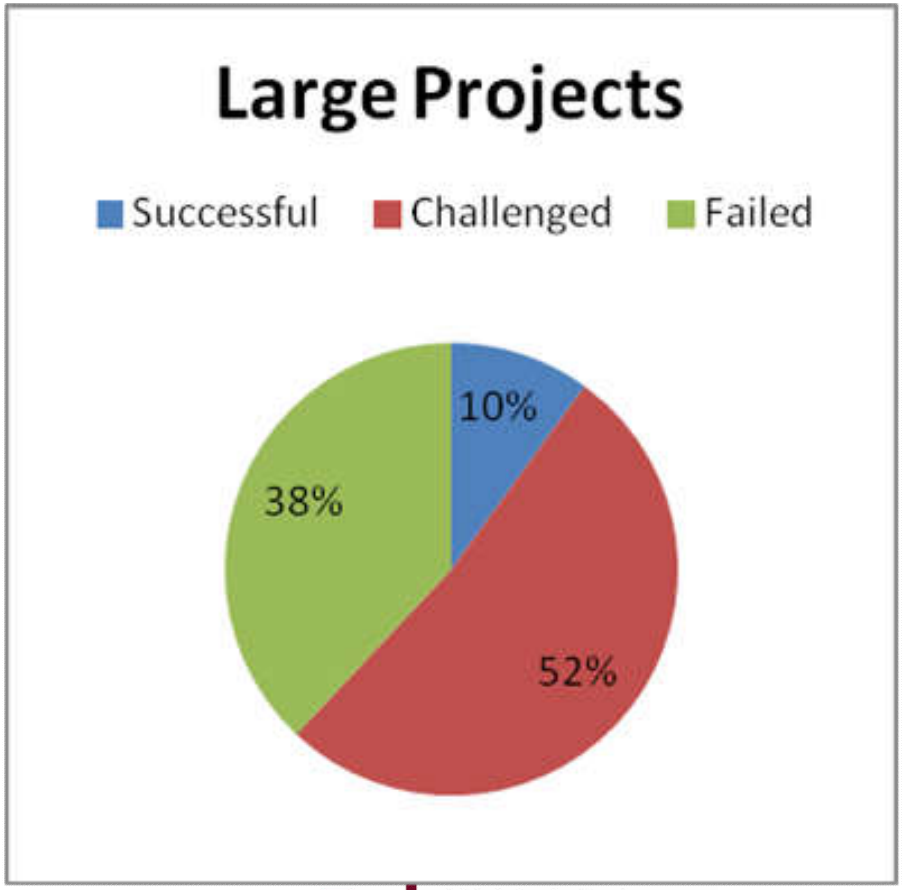
The effect of the project size

- Small project: budget is lover than $1 million
- Large project: budget is higher than $10 million

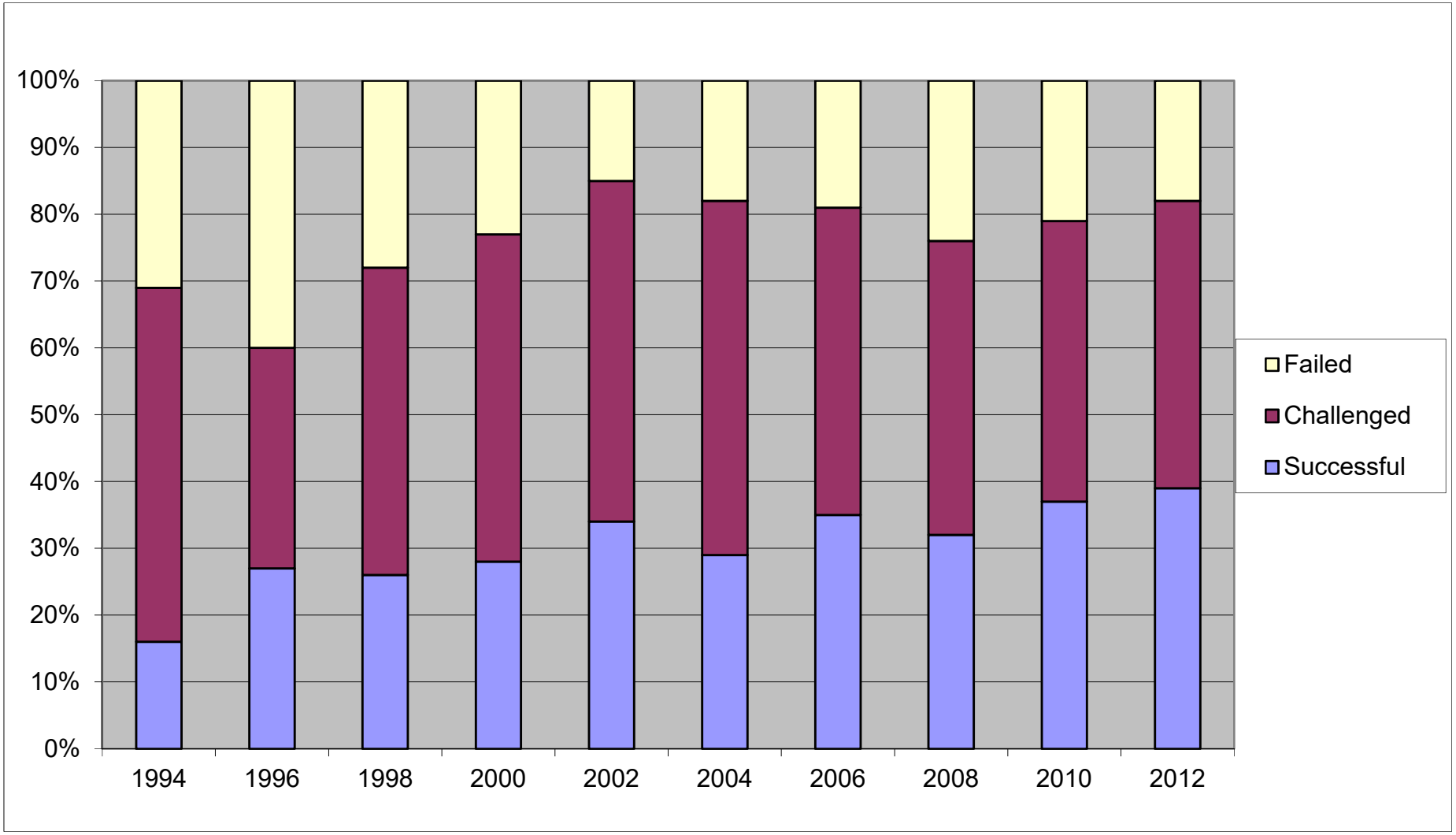


The effect of the project size

Sun Tzu: „Management of many is the same as management of few. It is a matter of organization.”

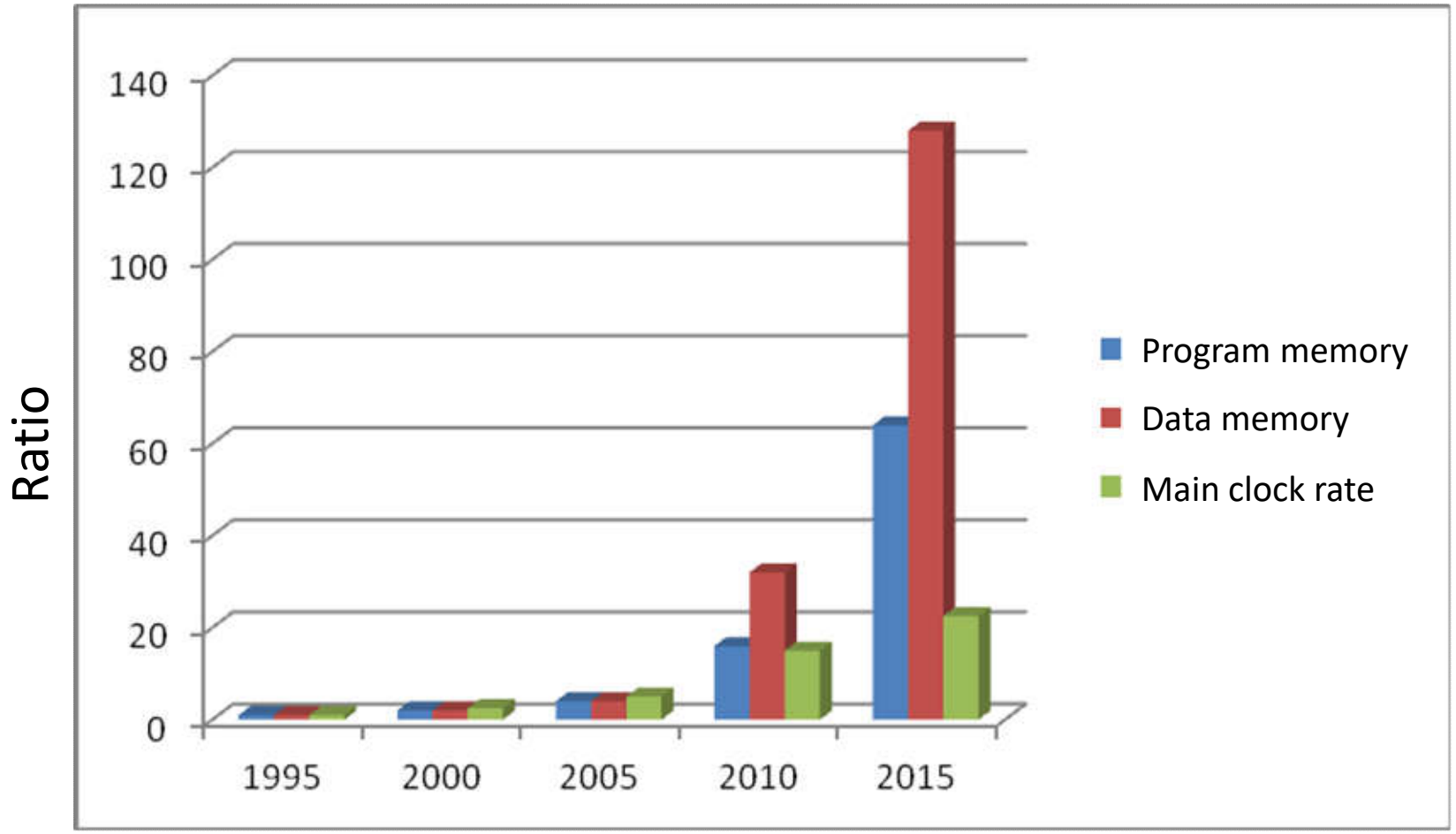


Is there a significant improvement?



Improvement of electronic devices

- Property improvements of $10 microcontrollers



There are a need for standards! But which standards can help us?

- There are many standards and these standards have many common goals and statemnts
  - ISO 15504: SPICE (*Software Process Improvement and Capability Determination*)
  - ISO 12207: *(Systems and software engineering -- Software life cycle processes*)
  - ISO 15288: *(Systems and software engineering -- System life cycle processes)*
  - ISO 9000: *(Quality management systems)*
  - CMMI for development *(Capability Maturity Model Integration)*
  - V-modell

CMMI

Introduction

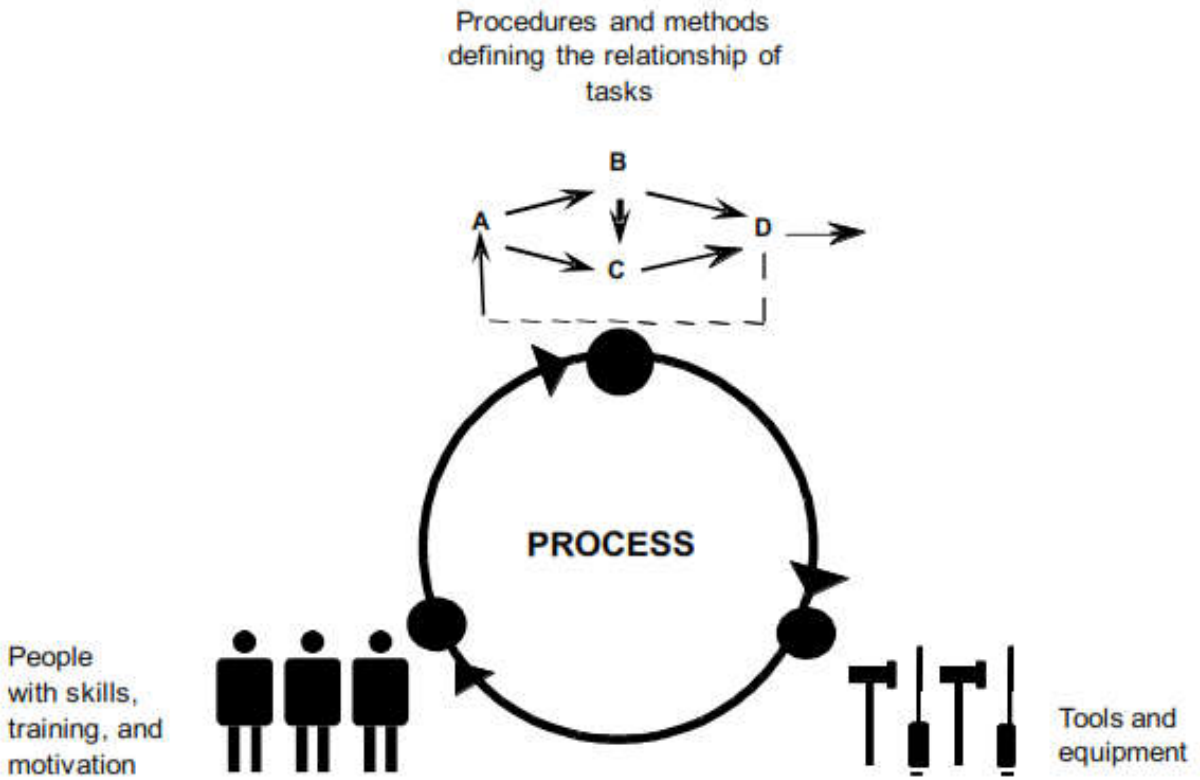
CMMI

Project planning

Capability Maturity Model Integration (CMMI)

- Free to download standard
  - Carnegie Mellon University maintain it
  - Current version used by us: CMMI for development 1.3 (about 400 pages). Published 2010
- The goal of CMMI is to give an guidance for companies to create and improve their process and projects.

What is a Process?



- The CMMI has 22 process area
  - The process areas descripts the goals, purpose of the area and methods and tools to improve the activity in the given area.

The approaches of CMMI

Continous and Staged representation

- Staged Representation
  - Mainly for newly started companies to create the process
  - Focus on the **overall state** of the organization. Uses **maturity levels** to characterize this overall state
- Continous Representation
  - Focus on individual process areas
  - Uses **capability levels** to rate the capability of one process area

Maturity levels of Staged representation

1. **level: Initial**
2. **level: Managed**
3. **level: Defined**
4. **level: Quantitatively Managed**
5. **level: Optimizing**

1st level: Initial

- Processes are ad-hoc and chaotic.
- The organization usually does not provide a stable environment to support processes.
- Success in these organizations depends on the competence and heroics of the people in the organization.
- In spite of this chaos, maturity level 1 organizations often produce products and services that work, but they frequently exceed the budget and schedule documented in their plans.
- Maturity level 1 organizations are characterized by a tendency to overcommit, abandon their processes in a time of crisis, and be unable to repeat their successes.

2nd level: Managed

- The projects have ensured that processes are planned and executed in accordance with policy.
- The projects employ skilled people who have adequate resources to produce controlled outputs.
- Ensure that existing practices are retained during times of stress.
- The status of the work products are visible to management at defined points (***milestones***).
- The work products and services satisfy their specified process descriptions, standards, and procedures.

3rd level: Defined

- Processes are well characterized and understood, and are described in standards, procedures, tools, and methods.
- The organization's set of standard processes, which is the basis for maturity level 3, is established and improved over time.
- Projects establish their defined processes by tailoring the organization's set of standard processes according to tailoring guidelines.
- The processes are described in more details like in 2nd level.
- There are continuous training for the employments.

4th level: Quantitatively Managed

- The projects establish quantitative objectives for quality and process performance and use them as criteria in managing projects
- Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers.
- Quality and process performance is understood in statistical terms and is managed throughout the life of projects.
- A critical distinction between maturity levels 3 and 4 is the predictability of process performance.

5th level: Optimizing

- The organization uses a quantitative approach to understand the variation inherent in the process and the causes of process outcomes.
- Maturity level 5 focuses on continually improving process performance through incremental and innovative process and technological improvements.
- At maturity level 4, the organization and projects focus on understanding and controlling performance at the subprocess level and using the results to manage projects. At maturity level 5, the organization is concerned with overall organizational performance using data collected from multiple projects.

Capability levels of Continous representation

0. level: Incomplete

1. level: Performed

2. level: Managed

3. level: Defined

0th level: Incomplet

- The process is not or partially performed.
- One or more of the **specific goals** of the process area are not satisfied.
- No generic goals exist for this level, since there is no reason to institutionalize a partially performed process

1st Level: Perfomed

- A performed process is a process that accomplishes the needed work to produce work products.
- The specific goals of the process area are satisfied.

- *Although capability level 1 results in important improvements, those improvements can be lost over time if they are not institutionalized.*

2nd level: Managed

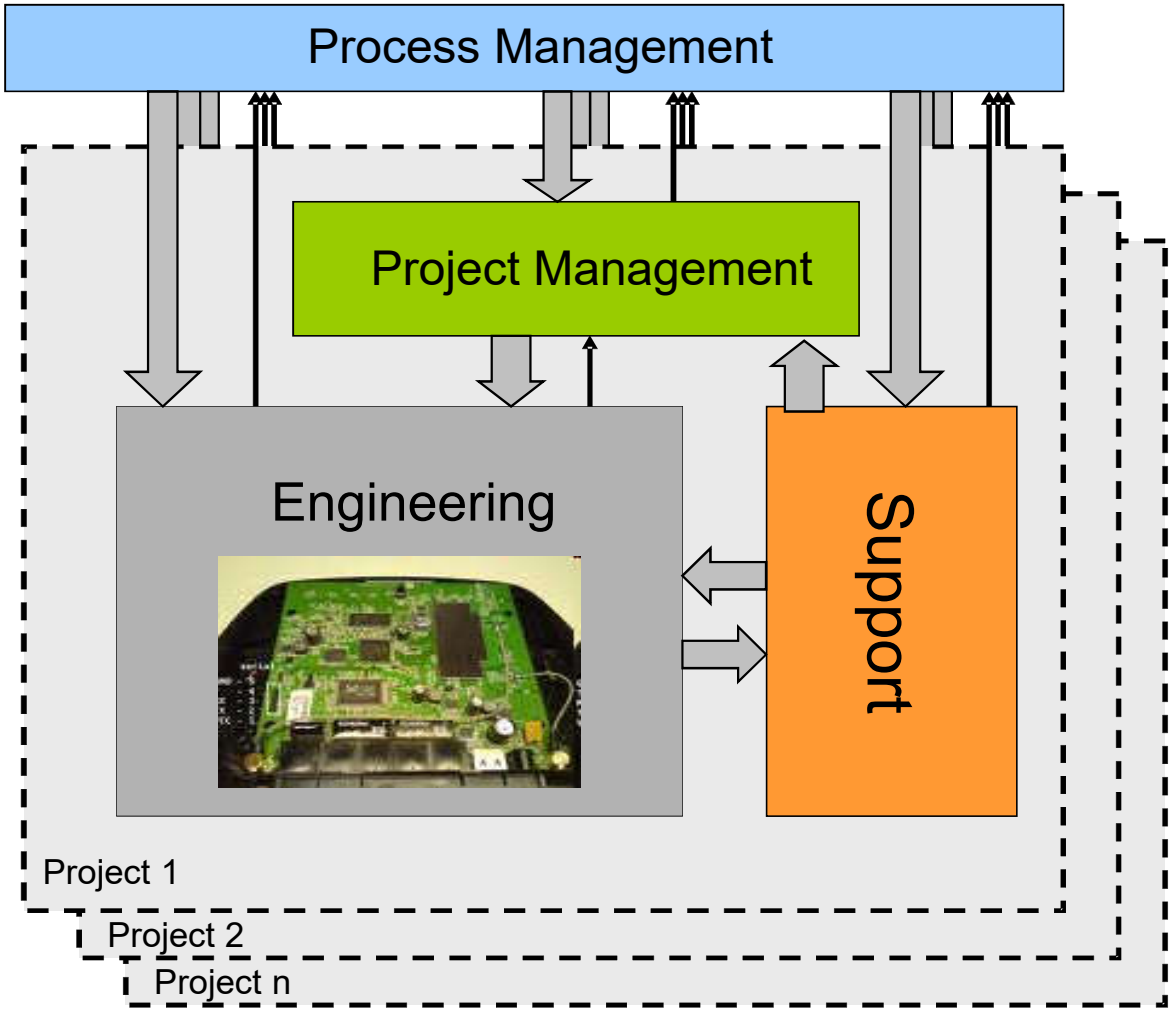
- A managed process is a performed process that is planned and executed in accordance with policy.
- Employs skilled people having adequate resources to produce controlled outputs.
- The process is monitored, controlled, and reviewed.
- Existing practices are retained during times of stress.

3rd level: Defined

- A defined process is a managed process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines.
- Has a maintained process description, and contributes process related experiences to the organizational process assets.
- A capability level 3 processes are typically described more rigorously than at capability level 2

The process areas of CMMI

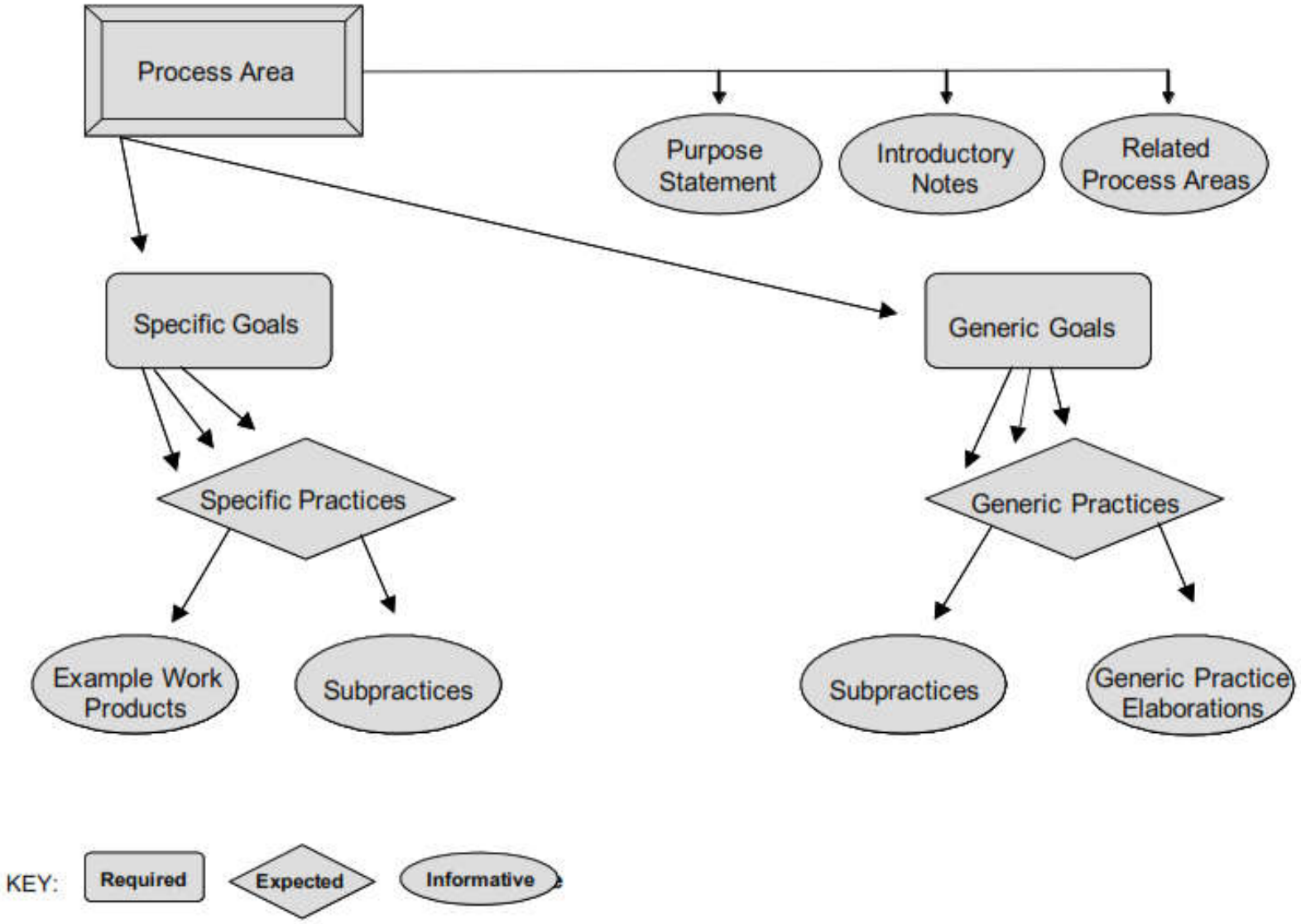
The process categories of CMMI



Connection between the Maturity and Capability levels

Process area	*Category*	*Maturity level*	*CL1*	*CL2*	*CL3*
Requirements Management	Project management	2	**Maturity level 2**		
Project Planning	Project management	2			
Project Monitoring and Control	Project management	2			
Supplier Agreement Management	Project management	2			
Measurement and Analysis	Support	2			
Process and Product Quality Assurance	Support	2			
Configuration Management	Support	2			
Requirements Development	Engineering	3	**Maturity level 3**		
Technical Solution	Engineering	3			
Product Integration	Engineering	3			
Verification	Engineering	3			
Validation	Engineering	3			
Organizational Process Focus	Process Management	3			
Organizational Process Definition	Process Management	3			
Organizational Training	Process Management	3			
Integrated Project Management +IPPD*	Project management	3			
Risk Management	Project management	3			
Decision Analysis and Resolution	Support	3			
Organizational Process Performance	Process Management	4	**Maturity level 4**		
Quantitative Project Management	Process Management	4			
Organizational Innovation and Deployment	Process Management	5	**Maturity level 5**		
Causal Analysis and Resolution	Support	5			

Description of Process Areas



Generic Goals

- **Generic Goal 1**: : Achieve Specific Goals
  - **GP1:** A Process specifikus gyakorlatok végrehajtása
- **Generic Goal 2**: Institutionalize a Managed Process
  - **GP 2.1:** Establish an Organizational Policy
  - **GP 2.2:** Plan the Process
  - **GP 2.3:** Provide Resources
  - **GP 2.4:** Assign Responsibility
  - **GP 2.5:** Train People
  - **GP 2.6**: Control Work Products
  - **GP 2.7**: Identify and Involve Relevant Stakeholders
  - **GP2.8**: Monitor and Control the Process
  - **GP2.9:** Objectively Evaluate Adherence
  - **GP2.10:** Review Status with Higher Level Management

Generic Goals *continue*

- **Generic Goal 3**: Institutionalize a Defined Process
  - **GP 3.1:** Establish a Defined Process
  - **GP 3.2:** Collect Process Related Experiences

Applying General Practices Connection to the Process Areas

- Process Areas closely connected to General Practices
  - **GP 2.2:** Planning the Process: **Project Planning**
  - **GP 2.3:** Providing Resources to the Project: **Project Planning**
  - **GP 2.4:** Assigning Responsibility: **Project Planning**
  - **GP 2.5:** Training People: **Organization Training**
  - **GP 2.6**: Controlling work products: **Configuration Management**
  - **…**

Project Planning and Management

Introduction

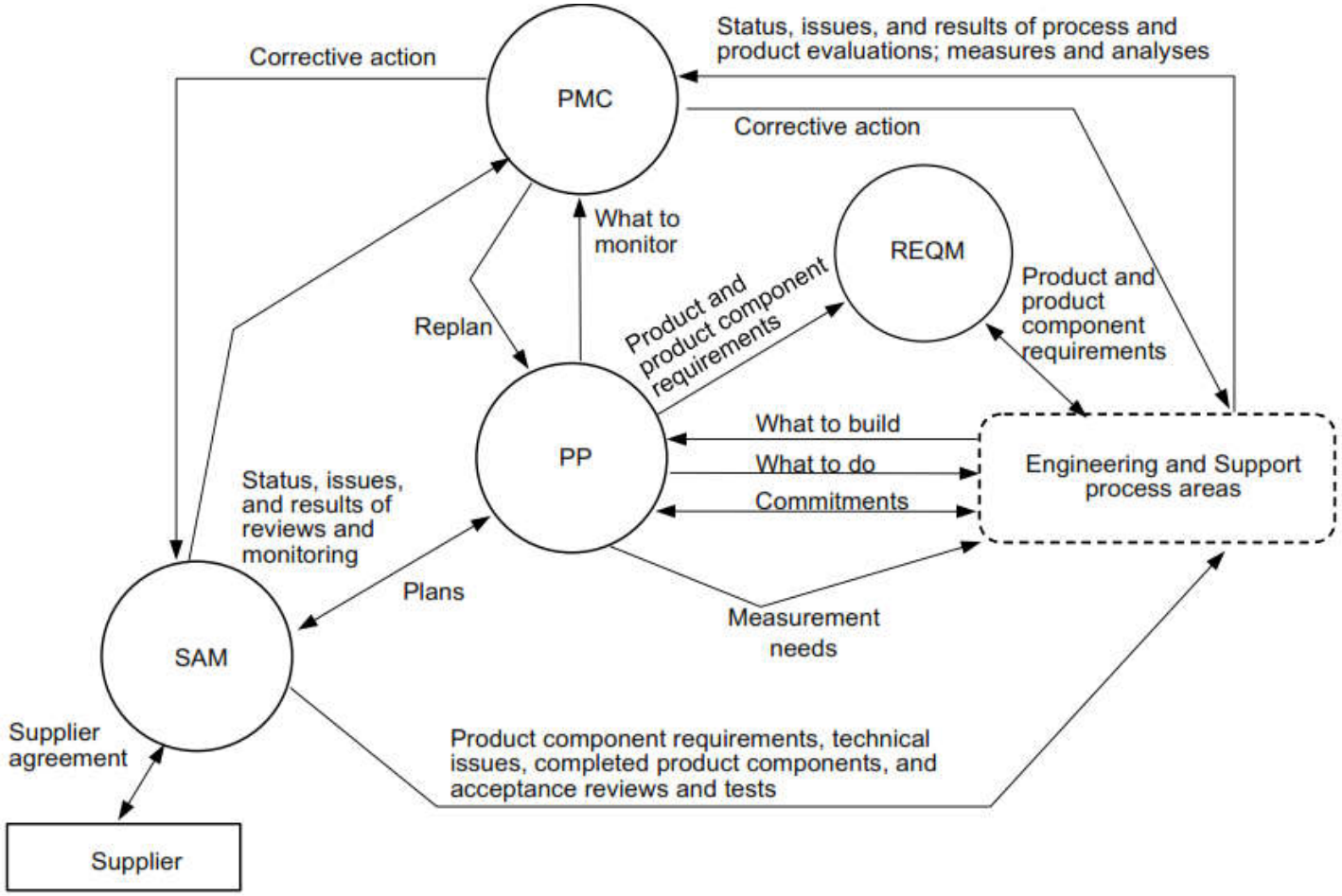
CMMI

Project planning

Process Areas in the Project Management Category

- **Maturity level 2**
  - Project Monitoring and Control (PMC)
  - **Project Planning (PP)**
  - Requirements Management (REQM)
  - Supplier Agreement Management (SAM)
- **Maturity level 3**
  - Integrated Project Management (IPM)
  - Quantitative Project Management (QPM)
  - Risk Management (RSKM)

Simplified View of Project Management

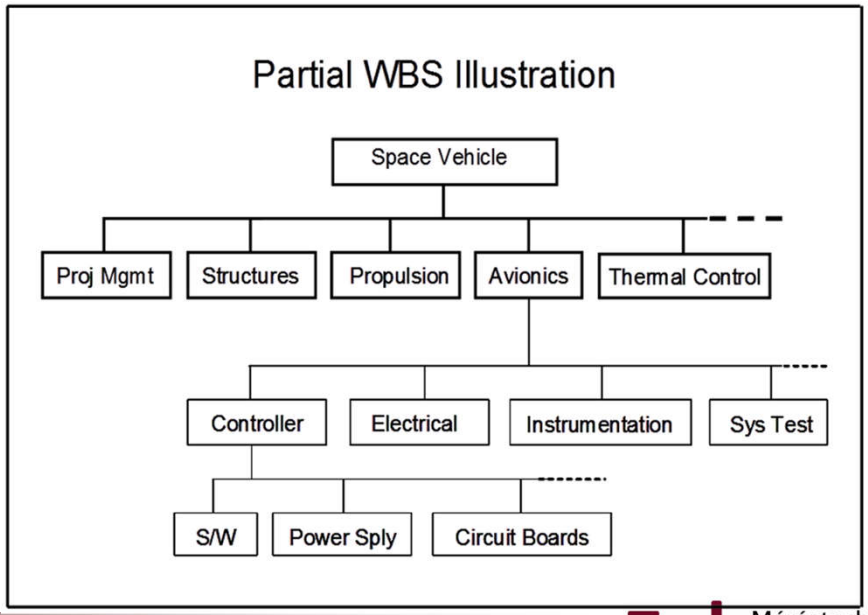


PMC = Project Monitoring and Control
PP = Project Planning
REQM = Requirements Management
SAM = Supplier Agreement Management

Project Planning

Project Planning SG1.

- **SG 1: Establish Estimates**
  - **SP 1.1:** Estimate project scope
    - Establish a top-level **Work Breakdown Structure (WBS)** to estimate the scope of the project. Identifying and organizing the logical units of work to be managed, which are called **Work Packages**.
    - Tools (***Mind-map, Gantt chart***) (*Mindview, OpenProj, MS project*). https://www.youtube.com/watch?v=lHMOQaKrXeg, NASA WBS handbook

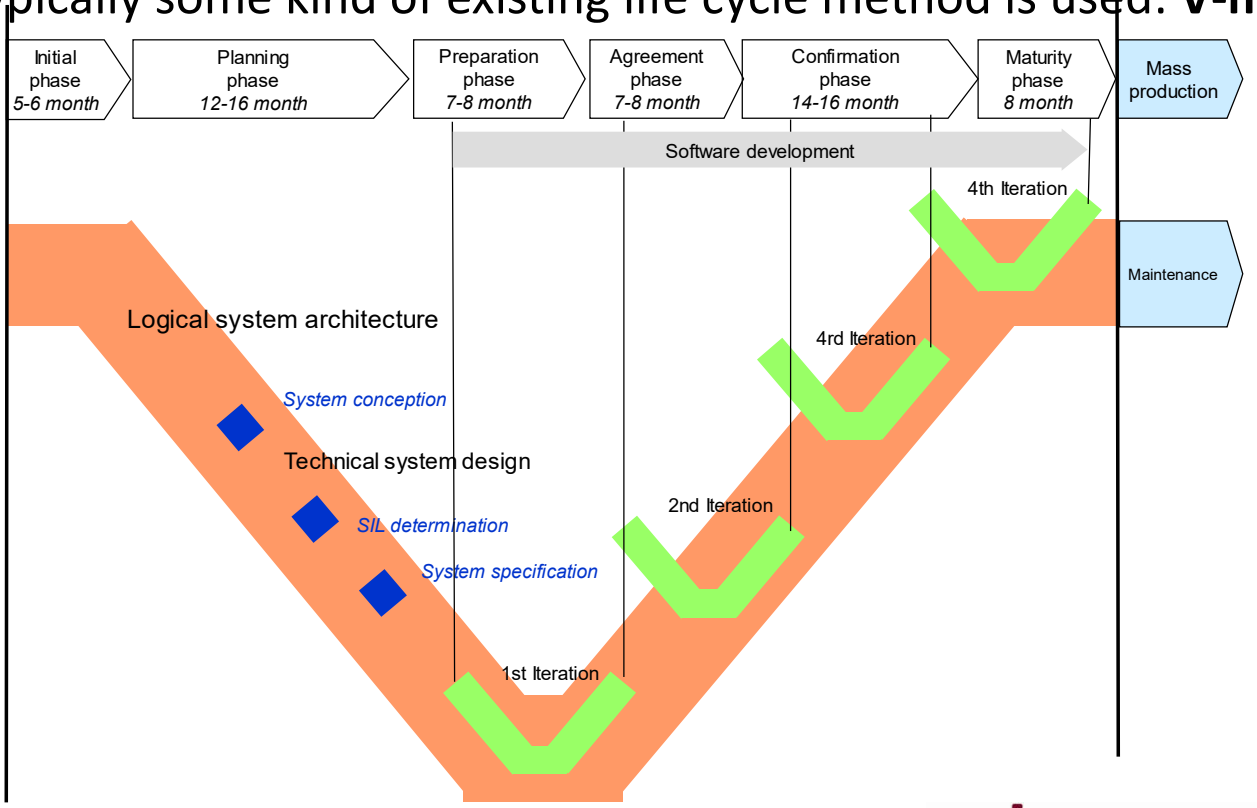


Project Planning SG1.

- **SP 1.2:** Establish Estimates of Work Product and Task Attributes
  - Number and complexity of requirements
  - Number and complexity of interfaces
  - Number of functions
  - Source lines of code
  - Number of inputs and outputs
  - Architecture elements
  - Amount of code to be reused versus created
  - Number of logic gates for integrated circuits
  - Number of parts (e.g., printed circuit boards, components, mechanical parts)
  - Physical constraints (e.g., weight, volume)
  - How agreeable or difficult the customer is

Project Planning SG1.

- **SP 1.3:** Define Project Lifecycle Phases
  - Understanding the project lifecycle is crucial in determining the scope of the planning effort and the timing of initial planning, as well as the timing and criteria (**critical milestones**) for replanning.
  - Typically some kind of existing life cycle method is used: **V-modell**



Project Planning SG1.

- **SP 1.4:** Estimate Effort and Cost
  - Use historical data
  - Include supporting infrastructure needs when estimating effort and Cost
  - Estimate effort and cost using models, historical data, or a combination of both

Example for cost model based estimations: **COCOMO (Constructive Cost Model)**

- **Definitions:**

  Eff: Effort Applied (in man months)

  KLOC: Kilo Line of Code (1000 code lines)

  Dt: Development Time (in man months)

  P: People required (number of developpers)

- **Estimation:**

$$Eff = a(KLOC)^b \text{ [man months]}$$

$$Dt = c(Eff)^d \text{ [months]}$$

$$P = Eff / Dt \text{ [people]}$$

Software project	a	b	c	d
Normál	2,4	1,05	2,5	0,38
Embedded	3,6	1,2	2,5	0,32

COCOMO example

Example for 10 000 code lines:

Embedded

$$Eff = 3.6\,(10)^{1.2} \approx 57 \text{ [man months]}$$

$$Dt = 2.5\ (57)^{0.32} \approx 9 \text{ [months]}$$

$$P = 57 / 9 = 6.3 \text{ [peoples]}$$

Non embedded

$$Eff = 2.4\,(10)^{1.05} \approx 27 \text{ [man months]}$$

$$Dt = 2.5\ (27)^{0.38} \approx 9 \text{ [months]}$$

$$P = 27 / 9 = 3 \text{ [peoples]}$$

Parkinson's law

- **C. Northcote Parkinson's law**

  „Work expands so as to fill the time available for its completion"

- **C. Northcote Parkinson's law in a generalized way**

  „The demand to a resource is tend to achieve its availability or capacity"

Project Planning SG2.

- **SG 2: Develop a project Plan**
  - **SP 2.1:** Establish the Budget and Schedule.
    - Identify major milestones.
    - Identify schedule assumptions: approximate time cost and its confidence
    - Identify constraints: like EMC lab is available on September only
    - Identify task dependencies: discovering critical pathes
    - Establish and maintain the budget and schedule: define activities with its starting point and durations
    - Establish corrective action criteria: specify the point when modification of the plan is needed

    - Many time the 8/80 rule is used: no activities should be longer than 80 hours, and shorter than 8 hours.

Project Planning SG2.

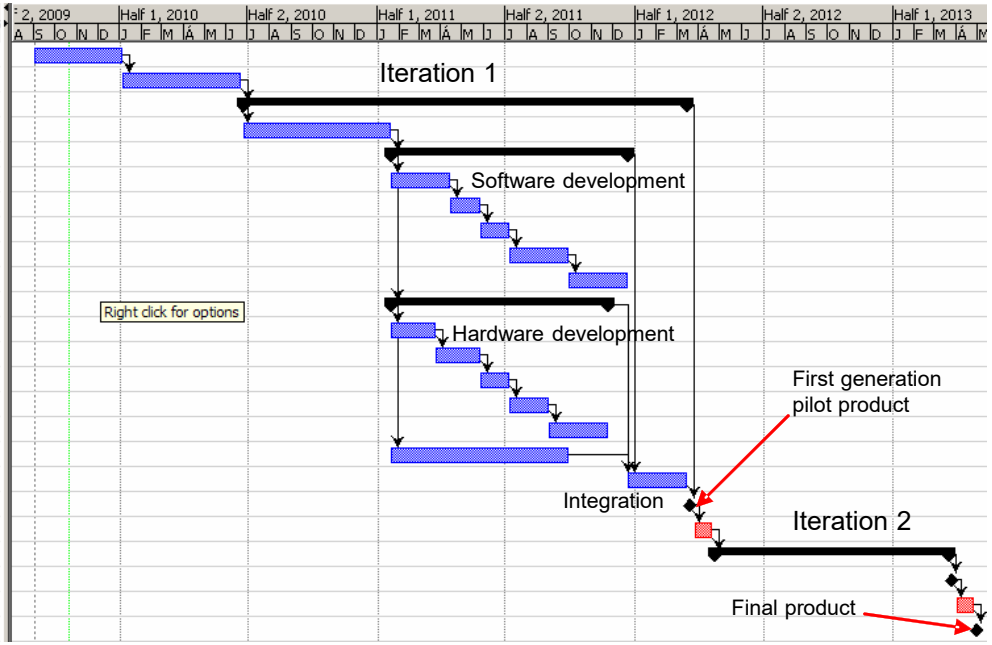
- **Tools**
  - **Gantt diagram:** *A Gantt diagram is invented by Henry L. Gantt in 1910-1915. Lines contain the activities the columns contain the months. The execution time of the activity is represented by a horizontal line in the diagram. Dependences between activities are signaled by arrows.*

Following data is needed to create a Gantt diagram:

- **Name of the activity**
- **Time costs of the activity**
- **Earliest starting point of the activity**
- **Dependency to other activities**

Gantt diagram example

	Name	Duration	Start	Finish	Predecessors
1	Requirement analisis	90 days?	2009.09.01. 8:00	2010.01.04. 17:00	
2	Logical system architecture design	120 days?	2010.01.05. 8:00	2010.06.21. 17:00	1
3	**Iteration 1**	**450 days?**	**2010.06.25. 8:00**	**2012.03.15. 17:00**	**2**
4	Technical system architecture design	150 days?	2010.06.25. 8:00	2011.01.20. 17:00	2
5	**Software**	**240 days?**	**2011.01.21. 8:00**	**2011.12.22. 17:00**	**4**
6	Software architecture design	60 days?	2011.01.21. 8:00	2011.04.14. 17:00	4
7	Software modul designs	30 days?	2011.04.15. 8:00	2011.05.26. 17:00	6
8	Software Modul Implementations	30 days?	2011.05.27. 8:00	2011.07.07. 17:00	7
9	Software Modul Test	60 days?	2011.07.08. 8:00	2011.09.29. 17:00	8
10	Software module integration, and integration test	60 days?	2011.09.30. 8:00	2011.12.22. 17:00	9
11	**Hardware**	**220 days?**	**2011.01.21. 8:00**	**2011.11.24. 17:00**	**4**
12	Hardware architecture design	45 days	2011.01.21. 8:00	2011.03.24. 17:00	4
13	Hardware modul designs	45 days	2011.03.25. 8:00	2011.05.26. 17:00	12
14	Hardware modul implementation	30 days?	2011.05.27. 8:00	2011.07.07. 17:00	13
15	Hardware Modul Test	40 days?	2011.07.08. 8:00	2011.09.01. 17:00	14
16	Hardware module integration, and integration test	60 days?	2011.09.02. 8:00	2011.11.24. 17:00	15
17	Mechanic design	180 days?	2011.01.21. 8:00	2011.09.29. 17:00	4
18	System integration, integration test	60 days?	2011.12.23. 8:00	2012.03.15. 17:00	5;11;17
19	First generation pilot product	5 days?	2012.03.18. 8:00	2012.03.23. 17:00	3
20	User acceptance test	20 days?	2012.03.26. 8:00	2012.04.20. 17:00	19
21	**Iteration 2**	**240 days?**	**2012.04.23. 8:00**	**2013.03.22. 17:00**	**20**
37	Second generation product	5 days?	2013.03.25. 8:00	2013.03.29. 17:00	21
38	User acceptance test	20 days?	2013.04.01. 8:00	2013.04.26. 17:00	37
39	Final product	5 days?	2013.04.29. 8:00	2013.05.03. 17:00	38



Project Planning SG2.

- **SP 2.2:** Identify Project Risks: Identify and analyze project risks
  - Indentifying documenting and priories risks. Risk are potential problems that can occur during the project.
- **SP 2.3:** Plan Data Management
  - What type of internal and release documents will be created? What are the privacy and security requirements of these documents?
- **SP 2.4:** Plan the Project's Resources
  - What are the staff and equipment requirements? What are the critical equitments, critical staff members.
- **SP 2.5:** Plan Needed Knowledge and Skills
  - Is there hire of new staff required? Are there any training required?
- **SP 2.6:** Plan Stakeholder Involvement
  - Listing relevant stakeholders. Who and when should be questioned, asked?
- **SP 2.7:** Establish the Project Plan
  - Creating the overall project plan based on the above points.

Selecting project team members

- Individual knowledge of team members not enough for the success.
- If someone work effectively alone does not mean that he or she will be a good team member.
- If someone work well and feels oneself good in one team, that does not mean he or she will work well and feel oneself good at any team.
- Good skilled people with good teamwork moral does not mean an elective team alone.

A team can work efficiently if its members fits to the appropriate the team roles.

Belbin Team Roles

1. **Implementer: (implementer):** The Implementer takes their colleagues' suggestions and ideas and turns them into positive action. They are efficient and self-disciplined, and can always be relied on to deliver on time. They are motivated by their loyalty to the team or company, which means that they will often take on jobs everyone else avoids or dislikes. However, they may be seen as closed-minded and inflexible since they will often have difficulty deviating from their own well-thought-out plans, especially if such a deviation compromises efficiency or threatens well-established practices.
2. **Co-ordinator:** A Co-ordinator is a likely candidate for the chairperson of a team, since they have a talent for stepping back to see the big picture. Co-ordinators are confident, stable and mature and because they recognise abilities in others, they are very good at delegating tasks to the right person for the job. The Co-ordinator clarifies decisions, helping everyone else focus on their tasks. Co-ordinators are sometimes perceived to be manipulative and will tend to delegate all work, leaving nothing but the delegating for them to do
3. **Shaper:** The Shaper provides the necessary drive to ensure that the team is kept moving and does not lose focus or momentum. Shapers are people who challenge the team to improve. They are dynamic and usually extraverted people who enjoy stimulating others, questioning norms, and finding the best approaches for solving problems. The Shaper is the one who shakes things up. Shapers could risk becoming aggressive and bad-humoured in their attempts to get things done.
4. **Plant:** Plants are creative, unorthodox and generators of ideas. If an innovative solution to a problem is needed, a Plant is a good person to ask. Plants can tend to ignore incidentals. Multiple Plants in a team can lead to misunderstandings. Plants can also create problems with the timing of their ideas. The fact that the team has decided on a valid way forward and is now in the implementation stage will not stop the Plant from coming up with new solutions and disrupting the implementation process

Belbin Team Roles

5. **Resource investigator:** He or she is focused outside the team, and has a finger firmly on the pulse of the outside world. Where a Plant creates new ideas, a Resource Investigator will quite happily appropriate them from other companies or people. A good Resource Investigator is a maker of possibilities and an excellent networker, but has a tendency to lose momentum towards the end of a project and to forget to follow things up.
6. **Monitor-evaluator:** Monitor Evaluators are fair and logical observers and judges of what is going on in the team. Since they are good at detaching themselves from bias, they are often the ones to see all available options with the greatest clarity and impartiality. However, they can become very critical, damping enthusiasm for anything without logical grounds, and they have a hard time inspiring themselves or others to be passionate about their work.[
7. **Teamworker:** A Teamworker is the oil between the cogs that keeps the machine that is the team running smoothly. They are good listeners and diplomats, talented at smoothing over conflicts and helping parties understand one another without becoming confrontational. Since the role can be a low-profile one, the beneficial effect of a Teamworker can go unnoticed and unappreciated until they are absent, when the team begins to argue, and small but important things cease to happen. Because of an unwillingness to take sides, a Teamworker may not be able to take decisive action when it's needed.
8. **Complementer-finisher:** The Completer Finisher is a perfectionist and will often go the extra mile to make sure everything is "just right," and the things he or she delivers can be trusted to have been double-checked and then checked again. The Completer Finisher has a strong inward sense of the need for accuracy, and sets his or her own high standards rather than working on the encouragement of others. They may frustrate their teammates by worrying excessively about minor details and by refusing to delegate tasks that they do not trust anyone else to perform.

Color systems: INSIGHTS Discovery System

- **Fiery Red**
  - Strong willed leaders.
  - Eager to take risks.
  - Have lots of energy and always in motion.
  - Self confident.
  - Desires for control and power.
  - Usually inpatient, straight to the point peoples.
- **Sunshine Yellow**
  - Strongly extroverted and friendly.
  - Usually have good human relations.
  - They do not like the direct approach, much more prefer to persuade someone.
  - They like the democratic atmosphere

Color systems: INSIGHTS Discovery System

- **Earth Green**
  - Focus on values and deep relationships
  - They are reliable and do many things to be considered reliable by others
  - They are typically patient, relaxed and caring
  - They are stubborn

- **Cool Blue**
  - Introverted
  - Desire to know and understand the world around them
  - They prefer written communication in order to maintain clarity and precision.
  - Have a desire for analysis
  - They are suspicious and cold

Project Planning SG3.

- **SG 3: Obtain Commitment to the Plant**
  - **SP 3.1:** Review Plans That Affect the Project
  - **SP 3.2:** Reconcile Work and Resource Levels
  - **SP 3.3:** Obtain Plan Commitment