Management Practice

9. Performance and quality

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MPiE

10/11/2020

Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Understand relationship standards and regulations
- Understand the value of the application of standards
- Able to describe the V-model
- Able to describe the Agile methodology
- Able to describe the Scrum methodology
- Able to apply Agile to a project

Literature for this session:

http://agilemanifesto.org/

Performance and quality

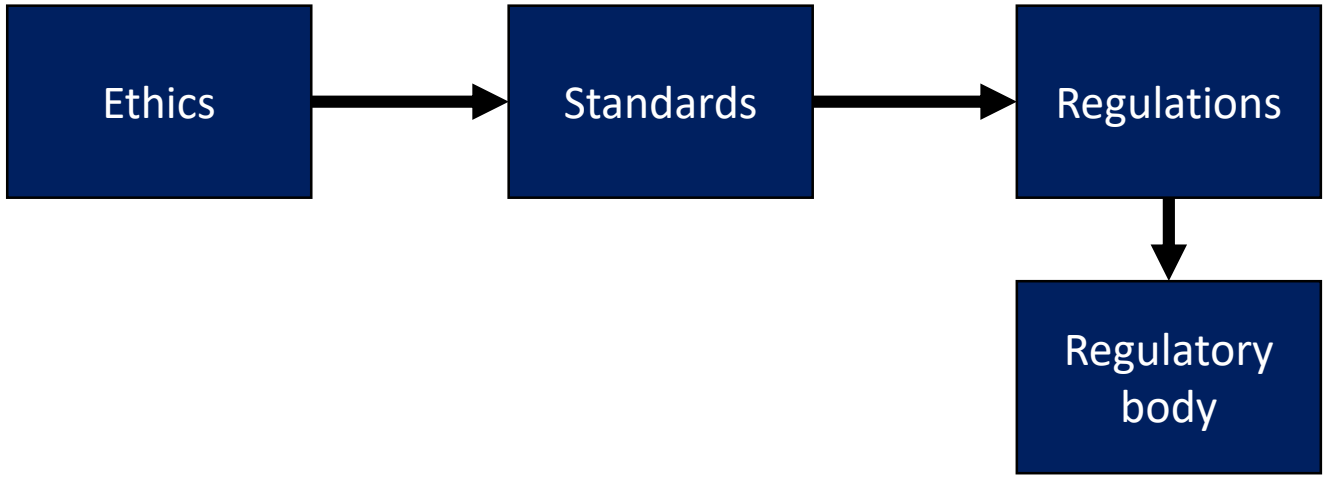
Quality driven management through:

- Ethics
- Standards
- Regulations

A range of management tools can be used to increase performance and quality

Ethics and regulations

- What is the difference between ethics and regulations?
- A regulation is a rule of order having the force of law, prescribed by a superior or competent authority, relating to the actions of those under the authority's control.



Source: Legal dictionary

Regulations VS Standards

Regulations	Standards
Mandatory	Voluntary
Created by legislator	Developed by standards organizations
Consultation according to government body's policy	Full open public consultation
Decided by government bodies	Based on consensus of all interested parties
Revised when legislator decides	Considered for revision every 5 years
Gives requirements to protect public interest	Provide specifications, test methods, codes, etc.

Source: BSI

How can standards be used to demonstrate regulations?

- Standards are market-based tools that can be used by Government to deliver better regulation: ‘Co-regulation’
- Can be used alongside accreditation, to verify conformity with a standard
- Benefits:

- Simplification of regulation
- Can incorporate technical development
- Reduce costs of Government policy delivery
- Legitimacy and market acceptance
- Business-friendly alternative to regulation

Quality management system

- ISO 9000 - Quality management - provide guidance and tools for companies and organizations who want to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved.

- ISO 9001:2015 sets out the criteria for a quality management system and is the only standard in the family that can be certified

Source: ISO.org

ISO 9001 - operations

The organization shall plan, implement and control the processes needed to meet the requirements for the provision of products and services, and to implement the actions by:

1) Determining the requirements for the products and services;

2) Establishing criteria for:

    a) the processes;

    b) the acceptance of products and services;

3) Determining the resources needed to achieve conformity to the product and service requirements;

4) Implementing control of the processes in accordance with the criteria;

5) Determining, maintaining and retaining documented information to the extent necessary:

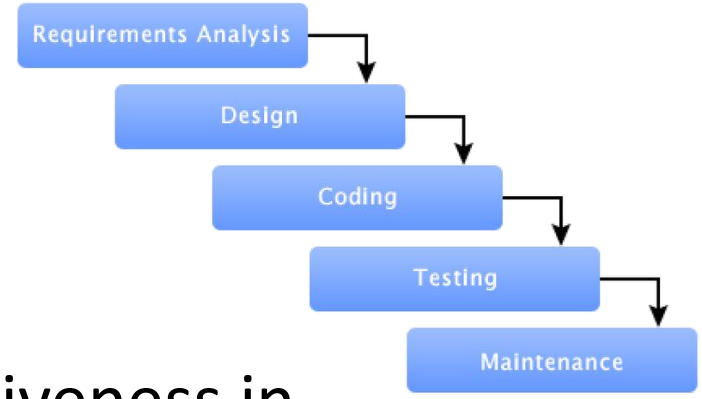
    a) to have confidence that the processes have been carried out as planned;

    b) to demonstrate the conformity of products and services to their requirements.

The output of this planning shall be suitable for the organization's operations. The organization shall control planned changes and review the consequences of unintended changes, taking action to mitigate any adverse effects, as necessary. The organization shall ensure that **outsourced processes are controlled**.

Project management

- The Waterfall model (1950s) assumes that the team has nearly perfect information about the project requirements, the solutions, and ultimately the goal. Hence, changes in requirements were not encouraged, and became an expensive affair.

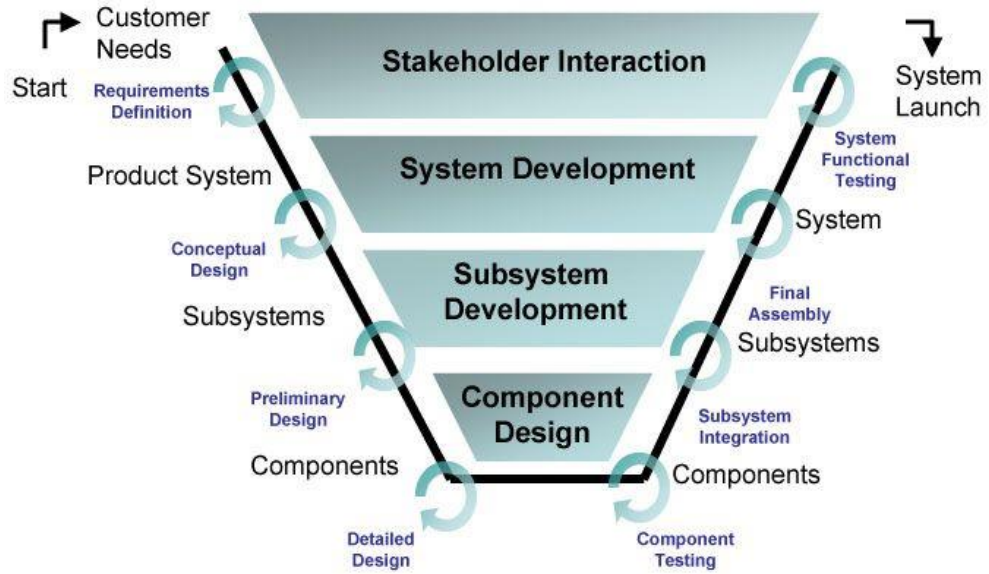


- It is a linear and sequential model.
- It became evident that the approach lacked effectiveness in addressing the needs of customers, managing rapidly changing scope, delivery time, and cost of the project

Source: Lei et al , A statistical analysis of the effects of Scrum and Kanban on software development projects, (2015); Calikus (2005)

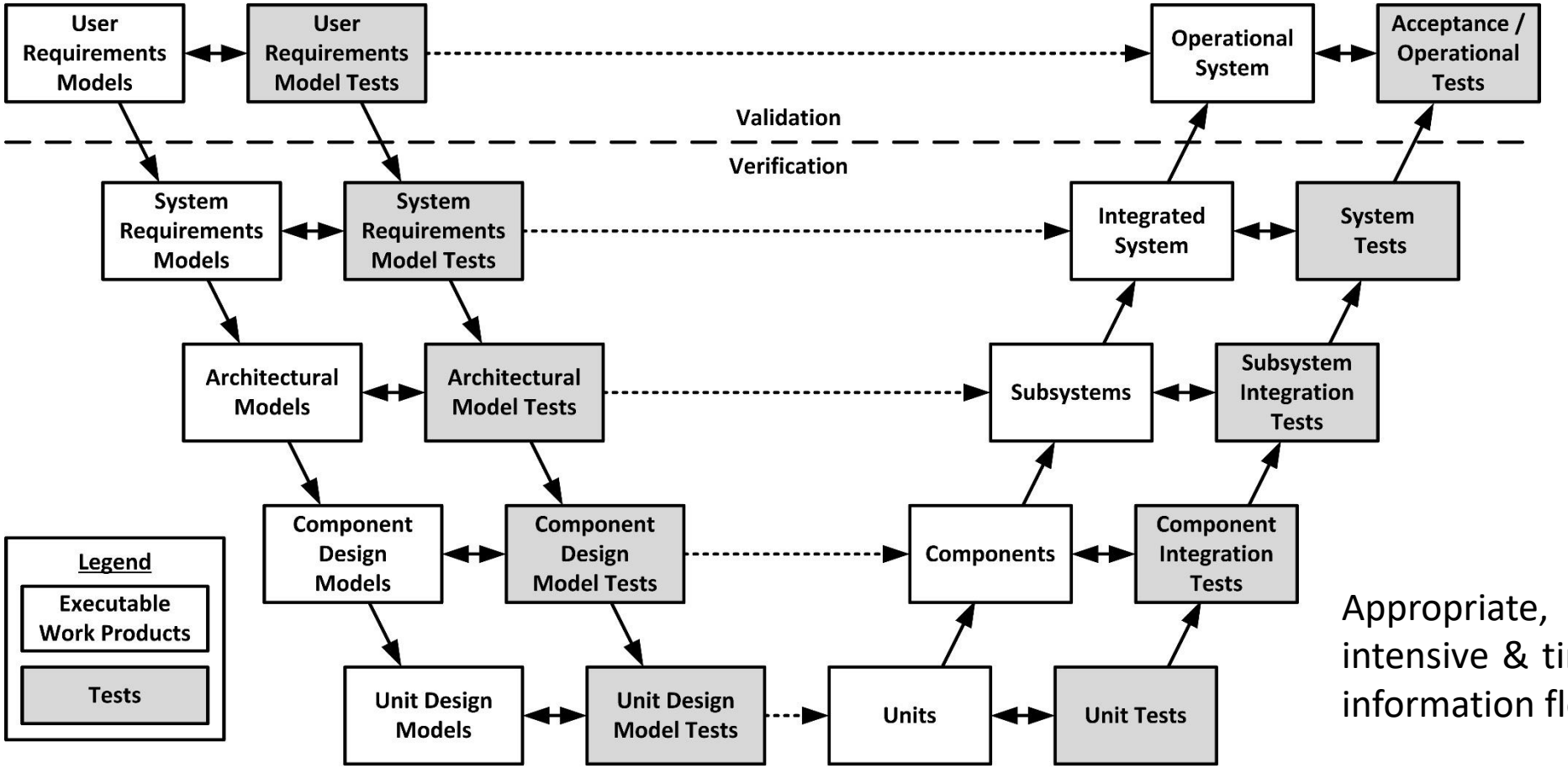
V-model

- In the V-model, testing and verification are performed at each stage of the system development, starting with the low-level components and ending with the higher-level components until the entire system has been verified.



Source: Lei et al , A statistical analysis of the effects of Scrum and Kanban on software development projects, (2015); MITSdm

V-model

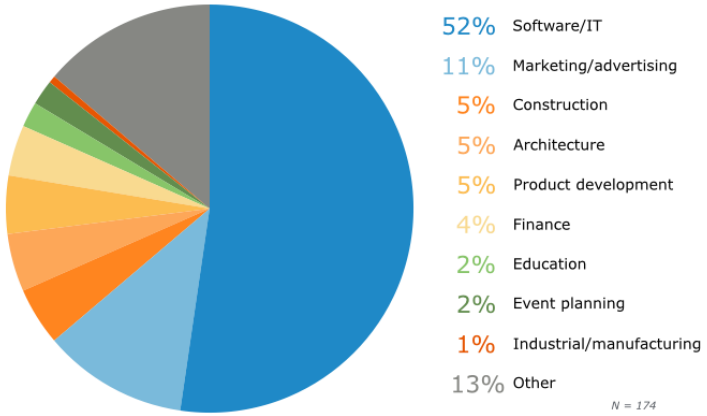


Appropriate, but time intensive & time delays on information flow back

Source: Software Engineering Institute

Agile

- In the mid-1990s, other software development methods evolved due to problems of these so-called “heavy weight software methodologies,” which are complex and require detailed documentation and expensive design.



Source: Lei et al , A statistical analysis of the effects of Scrum and Kanban on software development projects, (2015); Gartner and Software Advice

Agile

- Methods for agile software development constitute a set of practices for software development that have been created by experienced practitioners. These methods can be seen as a reaction to plan-based or traditional methods, which emphasize a rationalized, engineering-based approach.

- Ericksson defines it as “Agility means to strip away as much of the heaviness, commonly associated with the traditional software-development methodologies, as possible to promote quick response to changing environments, changes in user requirements, accelerated project deadlines and the like.”

- Agile methodologies are used to handle the challenges of managing complex projects during the development phase. These methodologies are a group of **incrementa**l and **iterative** methods that are seen as more effective, and have been used in project management.

Source: Dyba & Dingsøyr, Empirical studies of agile software development: A systematic review (2008)
Lei et al , A statistical analysis of the effects of Scrum and Kanban on software development projects, (2015)

Agile

A dominant idea in agile development is that the team can be more effective in responding to change if it can

- reduce the cost of moving information between people
- reduce the elapsed time between making a decision to seeing the consequences of that decision.

To reduce the cost of moving information between people, the agile team works to

- The team place people physically closer
- The team replace documents with talking in person and at whiteboards
- The Team improve the team's sense of community and morale so that people are more inclined to relay valuable information quickly.

To reduce the time from decision to feedback, the agile team

- The team makes user experts available to the team / part of the team
- The team works in an incremental fashion

Source: Cockburn & Highsmith (2001) Agile Software Development: The people factor

Agile

- It advocates adaptive planning, evolutionary development, early delivery, and continuous improvement, and it encourages rapid and flexible response to change

Source: Agile Alliance, What is Agile Software Development?

Agile evidence

- A review of 36 empirical studies on agile software development found that benefits were reported in the areas of customer collaboration, work processes for handling defects, learning in pair programming, thinking ahead for management and focusing on current work for engineers.
- However, it might work mainly for experienced, small development teams and it reduces the focus on design and architectural issues.
- The strength of evidence across the studies was very low.
- A more recent study in 2015 indicated that agile use improves time, budget and scope goals and is most effective at improving stakeholder satisfaction.
- It found there is a positive relationship between agile use and reported project success (n=1002 projects).

Source: Dyba & Dingsøyr, Empirical studies of agile software development: A systematic review (2008); Serrador & Pinto, Does Agile work? (2015)

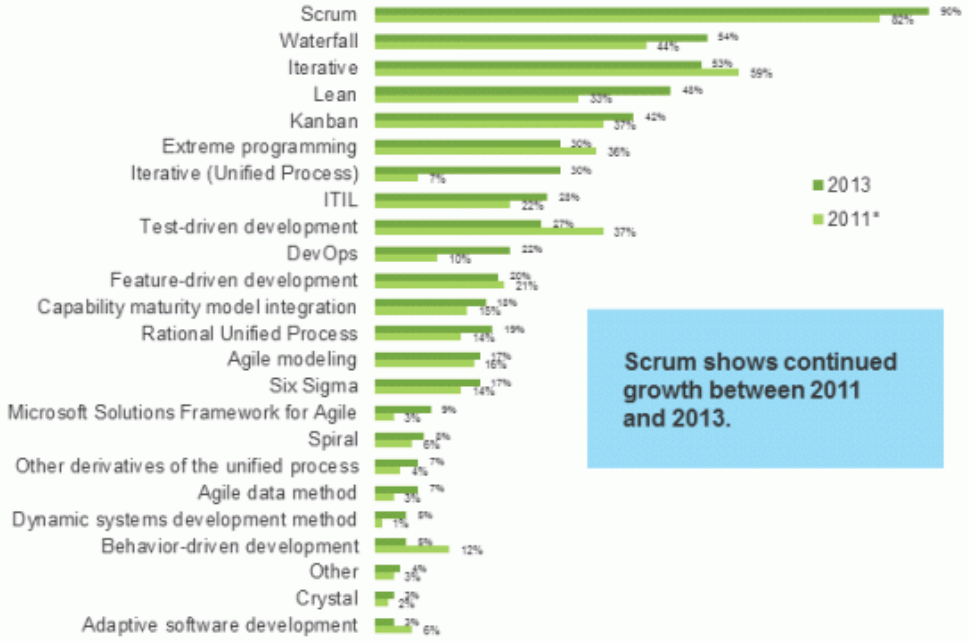
Scrum

- One of the models based on the Agile movement, known as Scrum, is based on principles of lean manufacturing

Source: Lei et al , A statistical analysis of the effects of Scrum and Kanban on software development projects, (2015); The American Society of Mechanical Engineers; Lean Enterprise Institute, Inc.

Scrum

Scrum, iterative, and waterfall are the most common approaches



Base: 149 IT professionals from organizations that are planning to implement or have implemented Agile;
*205 IT professionals from organizations that are planning to implement or have implemented Agile
Source: Q3 2013 Global Agile Software Application Development Online Survey;
*November 2011 Global Agile Software Application Development Online Survey

Scrum

- Scrum has been designed to manage rapidly-changing project requirements by improving communication between project developers, project owners, and other team members.

- Scrum is based on empirical process control theory, is an iterative and incremental project management methodology to control risk and optimize the predictability of a project through transparency, inspection and adaptation.

- Survey based results have indicated that Scrum can lead to successful qualitative software development projects.

Source: Lei et al , A statistical analysis of the effects of Scrum and Kanban on software development projects, (2015)

Scrum

- Transparency: The process must be visible to everyone who is involved in the project.
- Inspection: Scrum users must inspect Scrum artifacts frequently to detect problems in early stages.
- Adaptation: If an inspector determines that some aspects of the project are unacceptable and outside of the project scope, the process can be adjusted to avoid further problems.

Source: Lei et al , A statistical analysis of the effects of Scrum and Kanban on software development projects, (2015)

Scrum

- The three main artifacts that do result from the Scrum development process are the **Product Backlog**, the **Sprint Backlog** and the **Burndown Chart**.

- **Product Backlog:**
  The Product Backlog is an ordered list of everything that might be needed in the product and is the single source of requirements for any changes to be made to the product. The Product Backlog is never complete, it only lays out the known and best understood requirements. Product Backlog is dynamic, it consistently changes to identify what the product needs to be useful.

Source: www.umsl.edu/~sauterv/analysis/Fall2013Papers/Buric/agile-methodologies/scrum/scrum-artifacts.html

Scrum

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Source: www.umsl.edu/~sauterv/analysis/Fall2013Papers/Buric/agile-methodologies/scrum/scrum-artifacts.html

Scrum

- **The Sprint Backlog** defines the work the Development Team will perform to turn Product Backlog items into a “Done” Increment. The Sprint Backlog makes visible all of the work that the Development Team identifies as necessary to meet the Sprint Goal.

- **The Increment** is the sum of all the Product Backlog Items (PBI) completed during a Sprint and all previous Sprints. At the end of a Sprint, the new Increment must be “Done,” which means it must be in usable condition and meet the Scrum Team’s Definition of “Done.” It must be in usable condition regardless of whether the Product Owner decides to actually release it.

Source: www.umsl.edu/~sauterv/analysis/Fall2013Papers/Buric/agile-methodologies/scrum/scrum-artifacts.html

Steps

Steps

1. Plan–Build–Test–Review Small feature set – Suitable “product”

2. Repeat (1) Roughly 3 weeks per sprint (enough planning to complete cycle)

3. Reach a “shippable” product

Roles: Product Owner (defines the features of the product); Scrum master (manages to process, keep the process going), Team members (developers, tester, etc.)

Documents

Product Backlog, product owners create a ranking list of features (Changeable with every sprint).

User stories, describes features. It follows: **As an** *user* **I need a** *feature* **so that** *solves a requirement.* These user stories go to the **sprint backlog** to estimate required work (size of the task) in the sprint. Commitment made to complete these.

Burndown chart shows the progress during the sprint on the completion of tasks in the sprint backlog. It should be zero when the work is completed.

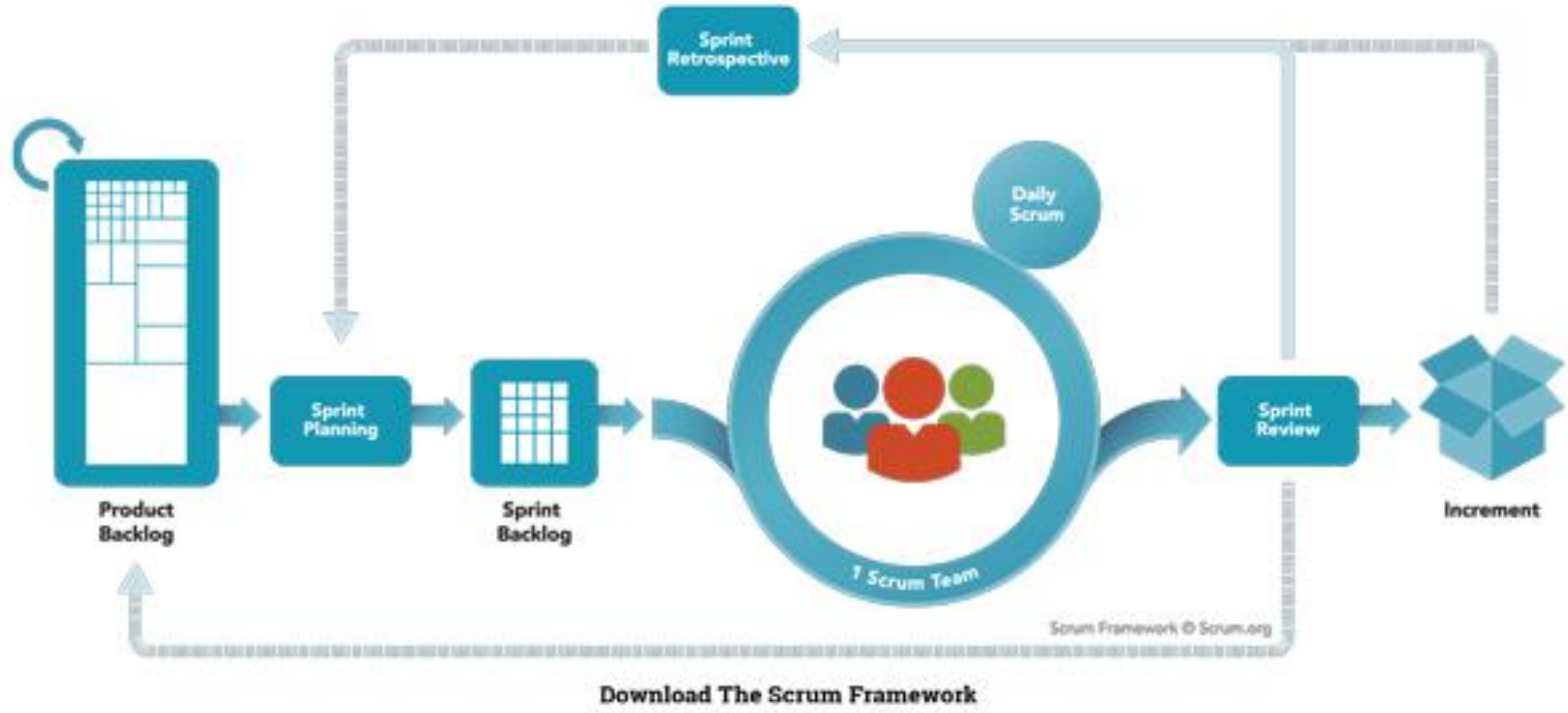
Discussions (ceremonies)

Sprint planning: everyone meets to discuss the user stories and estimate the relevant sizes.

Daily Scrum is a short stand-up meeting to discuss what has been completed since last time, what is being worked on and barriers.

Sprint review takes place at the end of the sprint and the result is presented to product owner. *Retrospective meeting* to see how the progress can be improved.

Scrum

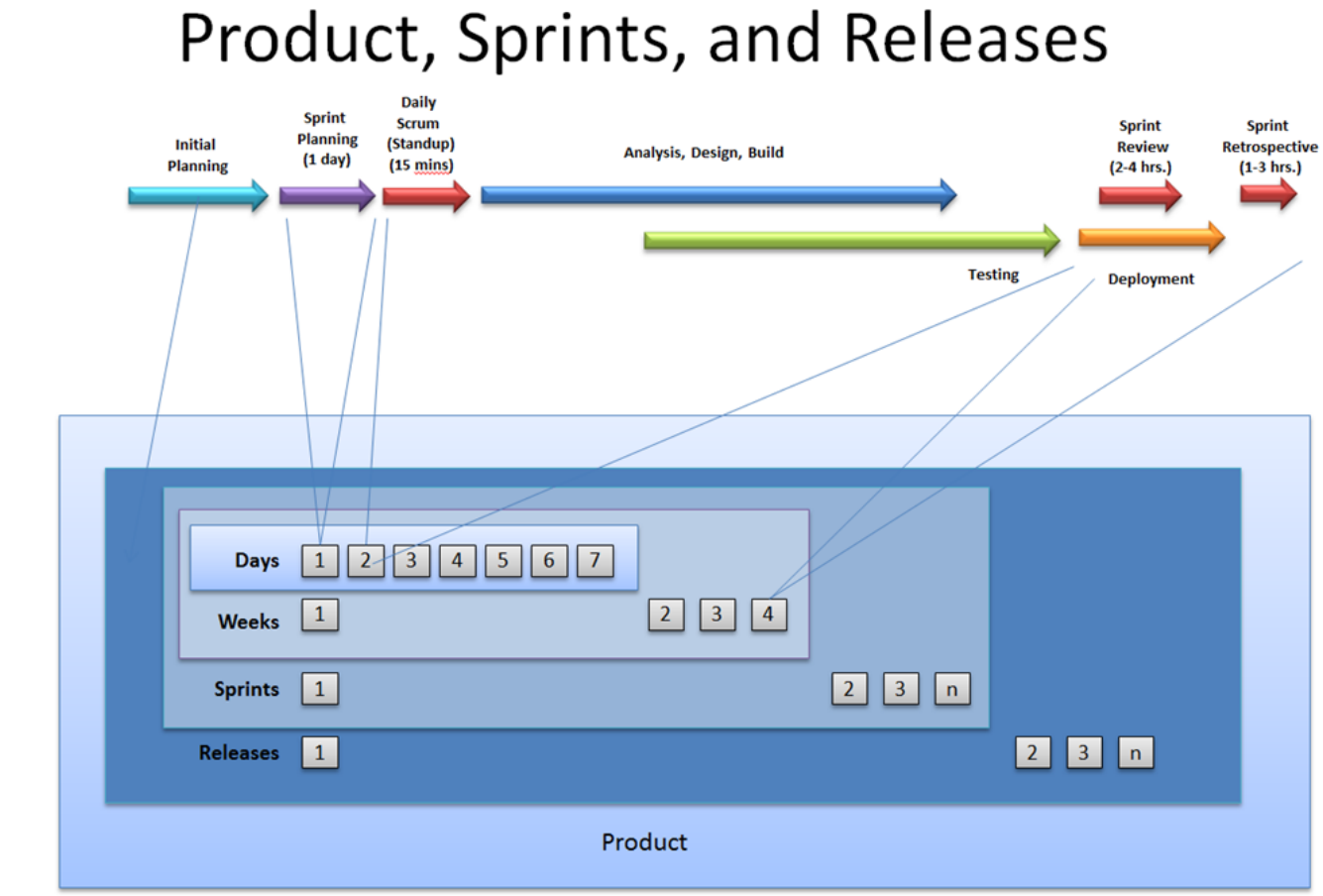

Sprint Retrospective
Daily Scrum
Sprint Planning
Sprint Review
Product Backlog
Sprint Backlog
Increment
1 Scrum Team
Scrum Framework © Scrum.org
Download The Scrum Framework

Scrum board

Backlog (user stories - PBI)	Tasks			
	To do	**In progress**	**Testing/verification**	**Done (well defined)**
As an user …	Code … Test …			
As an user …	Test …	Code …		
As an user …		Code …	Test …	
As an user …				As an user …

Label who takes on certain tasks

Scrum timeline



Sprint planning meeting (2 hrs)

- Understand the roles of the Product Owner, Scrum Master, and Scrum Development Team in Sprint Planning.
- Define Sprint Planning Meeting and sprint execution maximum duration. For example 2 hours planning meeting to define a 2 week sprint.
- Determine **which items** from the Product Backlog (or user stories) will be committed to the sprint backlog (make sure it fits the 2 week timeline).
- Set tasks that are needed to complete PBIs (some tasks will be identified as you go through the sprint and these will be updated).
- So, Product Backlog need to be available (this can be set in previous backlog refinement meeting) and then 1) Select BPIs and 2) Set Tasks
- Product owner can help set priorities in BPIs.

Daily Scrum (15 min max)

Have scrummaster starts (show **Scrum board**)

Per person

- What did you do yesterday

- What are you doing today

- Any roadblocks – use “Park that” (do not go in details)

Have scrummaster end (show **Burndown chart** – update sprint backlog if needed)

Any unrelated PBIs identified go to the backlog and should not effect your sprint.

Sprint – Recap and preparation

- **Roles Selection:** Product Owner, a Scrum Master and team members.
- **Create product Backlog:** The Backlog is where you list out everything the project needs, ordered by importance. Keep in mind that the Backlog is never complete. As the project takes shape and new needs emerge, you will add to this. The Product Owner takes primarily responsible for this.
- **Plan your Sprint:** Pick tasks from the backlog to be completed in your first Sprint. Sprint's are time-limited. You can decide a time length that works for you, but they are always less than one month. During the Spring Planning, the team decides what tasks to include in this Sprint and who will be responsible for them.
- **Sprint** Team members work on their tasks, and everybody checks in on their progress at the Daily Scrum Meeting. This meeting lasts no more than 15-minutes and answers three questions: What did you work on yesterday? What will you work on today? Is there anything blocking your work today that you need help with?
- **Review your work:** At the end of the Sprint, the team reviews the work accomplished and presents their completed tasks.
- **Review your process:** During the Retrospective meeting, you'll review how the actual work process went and plan ways you can improve your work and be more efficient next time.
- **Repeat sprint**

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Questions?

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Management Practice

10. Agile applied

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10/11/2020

Agile

Agile is a process by which projects can be managed and implemented in small chunks of work

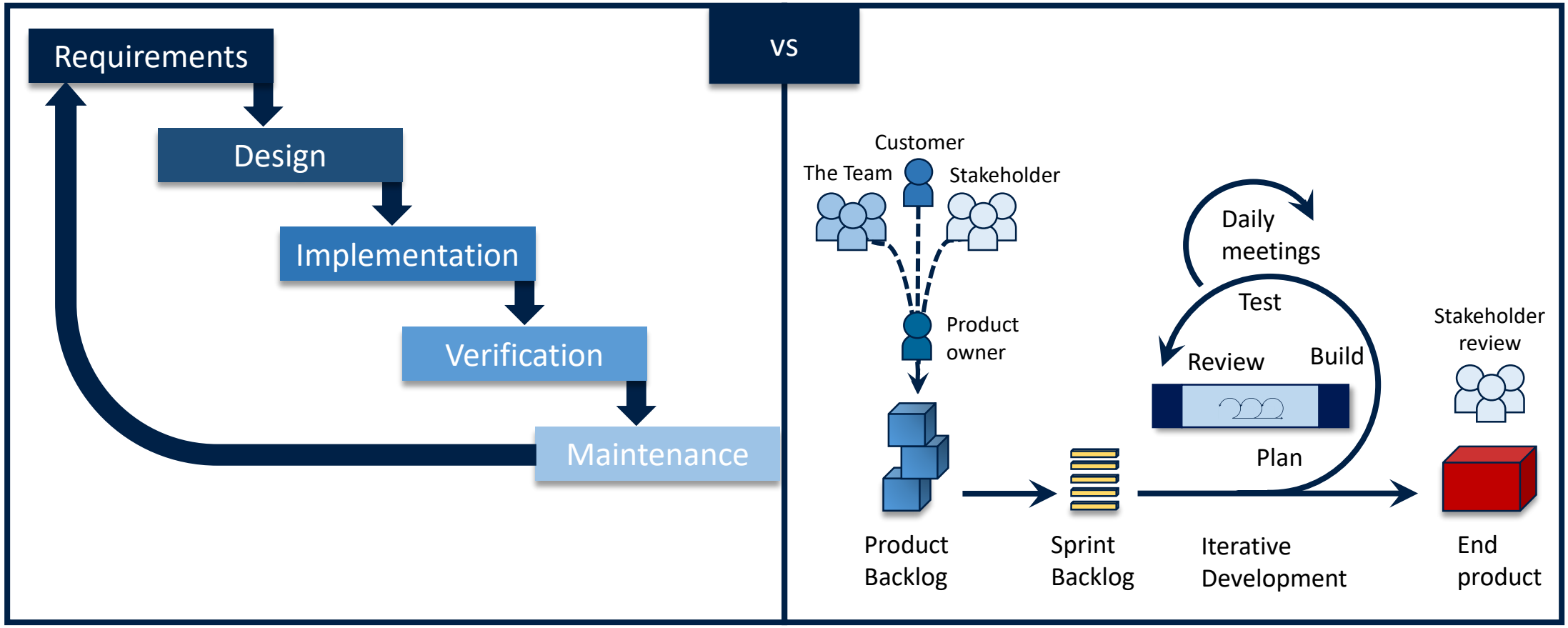
There is opportunities to assess a project‘s direction during the development cycle

It helps teams to provide quick responses to change

This process enables businesses to deliver part of the solution as they become ready

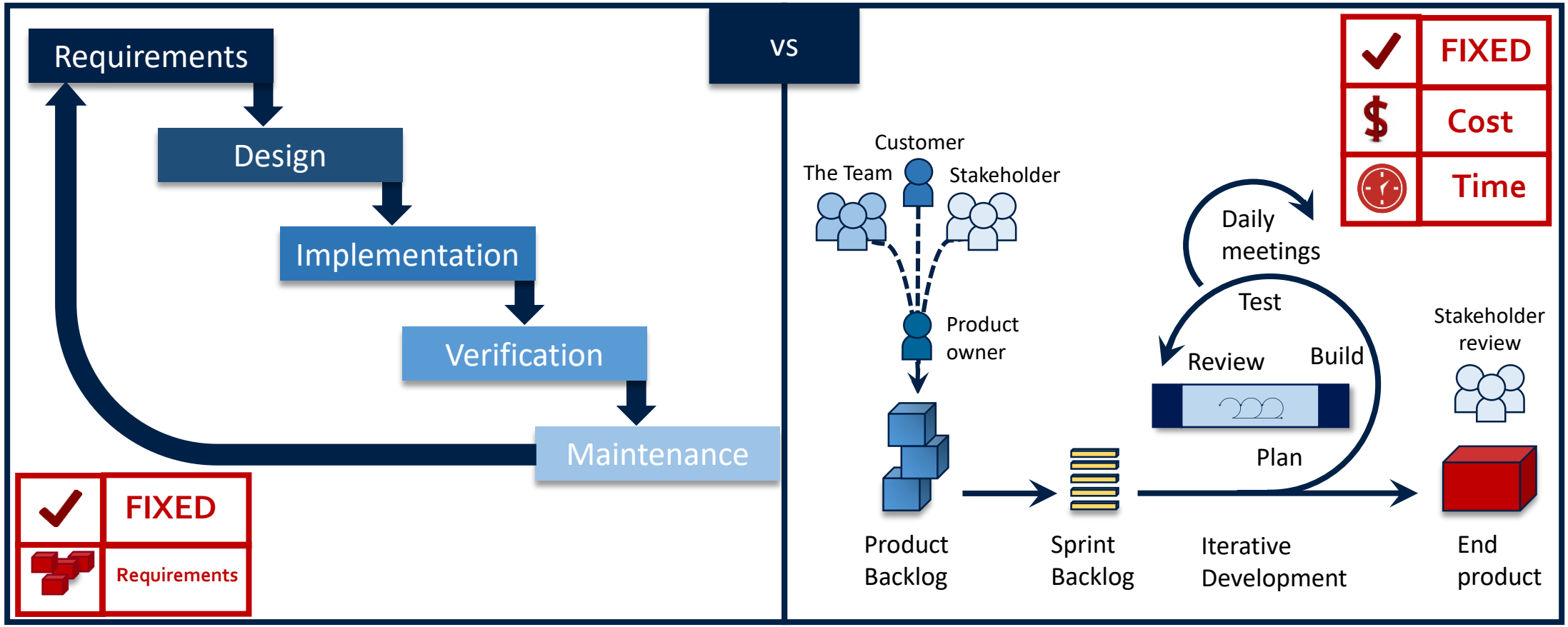
Source: Dr Rita Hendricusdottir

Waterfall approach vs Agile



Source: Dr Rita Hendricusdottir

Waterfall approach vs Agile



Source: Dr Rita Hendricusdottir

Agile Manifesto

We are uncovering better ways of developing software (products) by doing it and helping others do it. Through this work we have come to value:

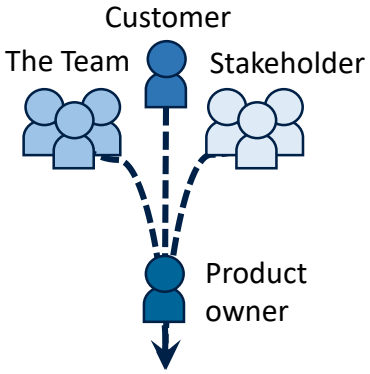
• Individual and interactions • Working software (products) • Customer collaboration • Responding to change	Over	• Process and tools • Comprehensive documentation • Contract negotiation • Follow a plan

Philosophy

‘Best business value emerges when projects are aligned to clear business goals, deliver frequently and involve the collaboration of motivated and empowered people.’

Source: Dr Rita Hendricusdottir

Agile – Team



People working together effectively are the foundation of any successful project.

Assign clear roles and responsibilities to each person representing the following interests:

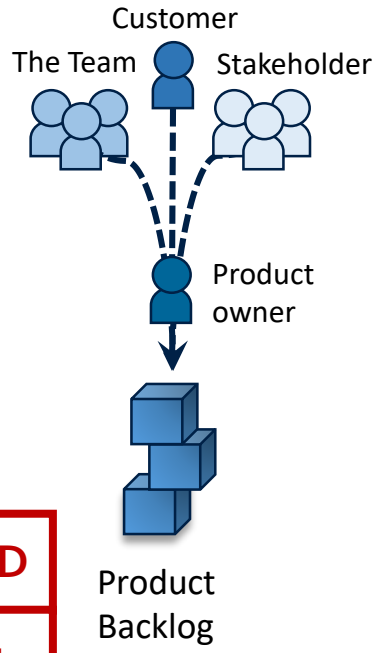
- Business
- Technical
- Management
- Process

At the same time:

- **respect** each other's knowledge, experience, skills and opinions
- take personal **responsibility** for their work and the dependence of the other team members of them
- Have the courage to **challenge** ways of working, to **improve** their team collaboration and working processes.

Source: Dr Rita Hendricusdottir

Agile – Product Backlog (1 day, group meeting)



List of all things that needs to be done within the project

Technical | User stories

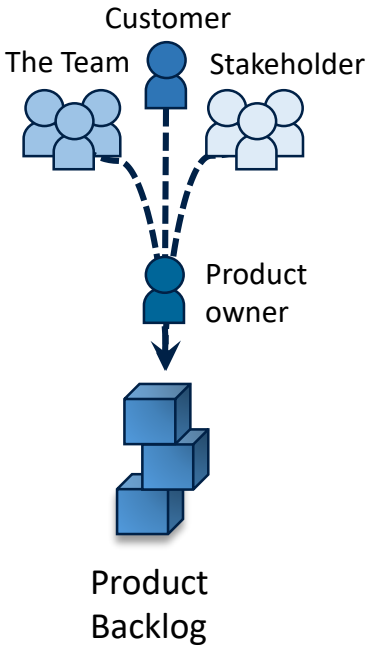
As a user **I want to see /need a** feature **so that** solves a requirement

Product Backlog / User stories	Priority
1. Setup server and database (Technical)	Must
2. Style page components based on sketch design (Technical)	Must
3. As a user I want to see one question per page so that I know which one to answer (User story)	Must
4. As a user I want to see a summary report so that I can see my class and review the questions it took to get there (User story)	Should
…	

✓	FIXED
$	Cost
🕒	Time

Source: Dr Rita Hendricusdottir

Agile – MoSCoW Prioritisation



Must have

- **M**inimum **U**sable **S**ubse**T**
- Without them, release will be useless
- Guaranteed delivery at the end of timebox

Mo

Should have

- Important requirements
- Need to have
- Without them, delivery is still usable

Necessary but not sufficient

- There is a workaround

S

W

- Non-value adding requirement
- Not required now, may be later
- Bottom of the pile
- Not important, not urgent

Will not have

Co

- Negotiable requirements
- Nice to have
- Minimum value
- Important, but not urgent

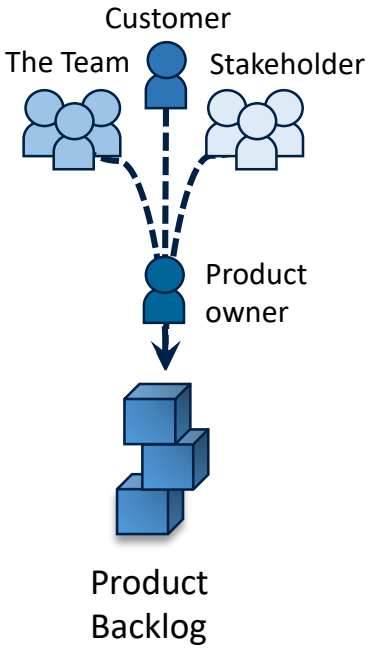
Could have

✓	FIXED
$	Cost
🕒	Time

Source: Dr Rita Hendricusdottir

Minimum viable product (MVP)

Exercise – Product Backlog



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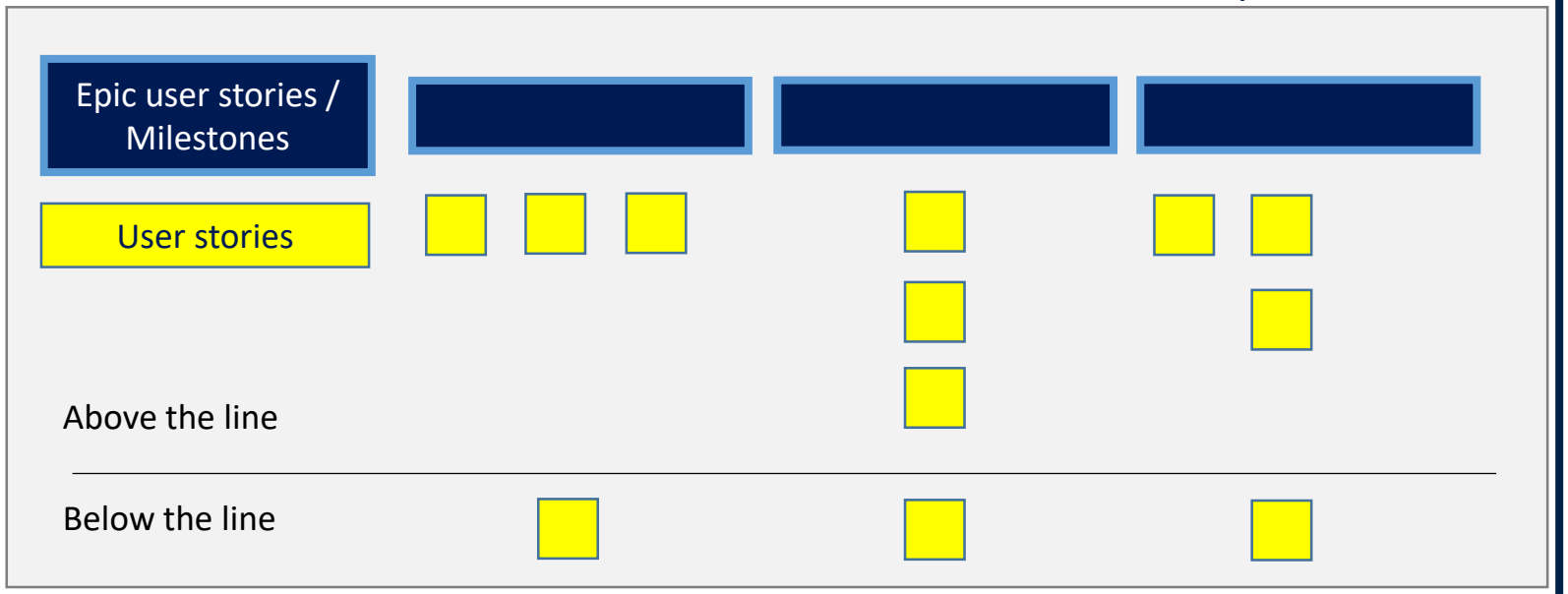
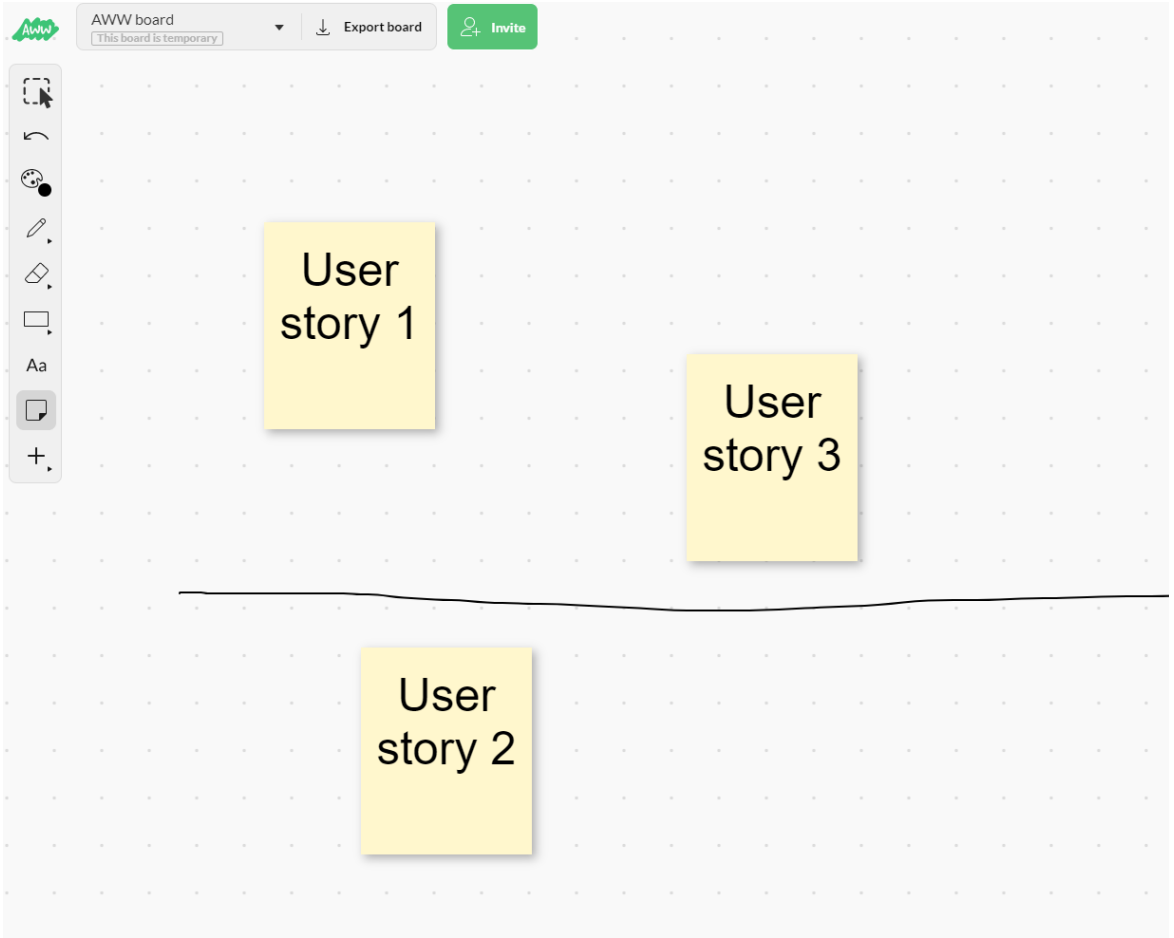


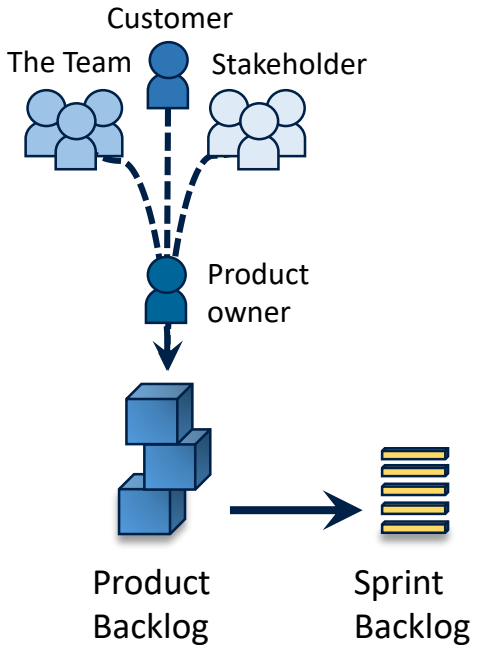
Source: Dr Rita Hendricusdottir

Setup Product Backlog (15 mins)



Source: www.awwapp.com

Agile – Sprint Backlog

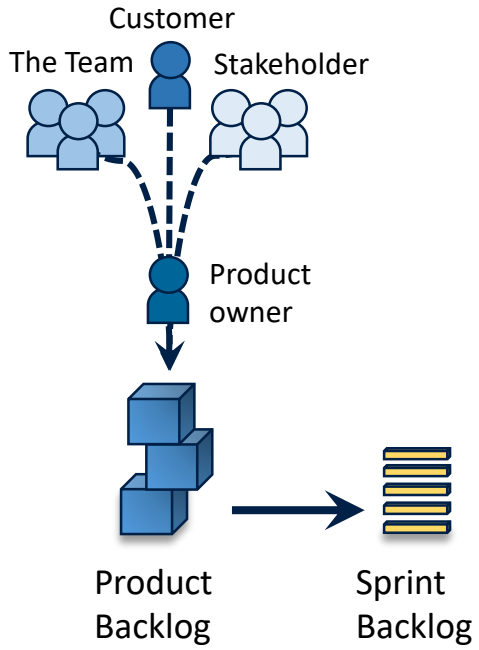


Sprint Backlog	Priority	Time
4. As a user I want to see a summary report so that I can see my class and review the questions it took to get there (User stories)	**Must**	2.75
4.1. I want to see what class my device is	Must	
4.2. I want to see all of the questions/decisions that I made so that I can review these	Should	
4.3. I see the date that the summary report was generated	Could	
4.4. I want to see a "start again" action so that I can do-over, plus guidance as to why I might want to use this	Could	
…		

Source: Dr Rita Hendricusdottir

Setup – Sprint Backlog (group of 2-3 rotating)

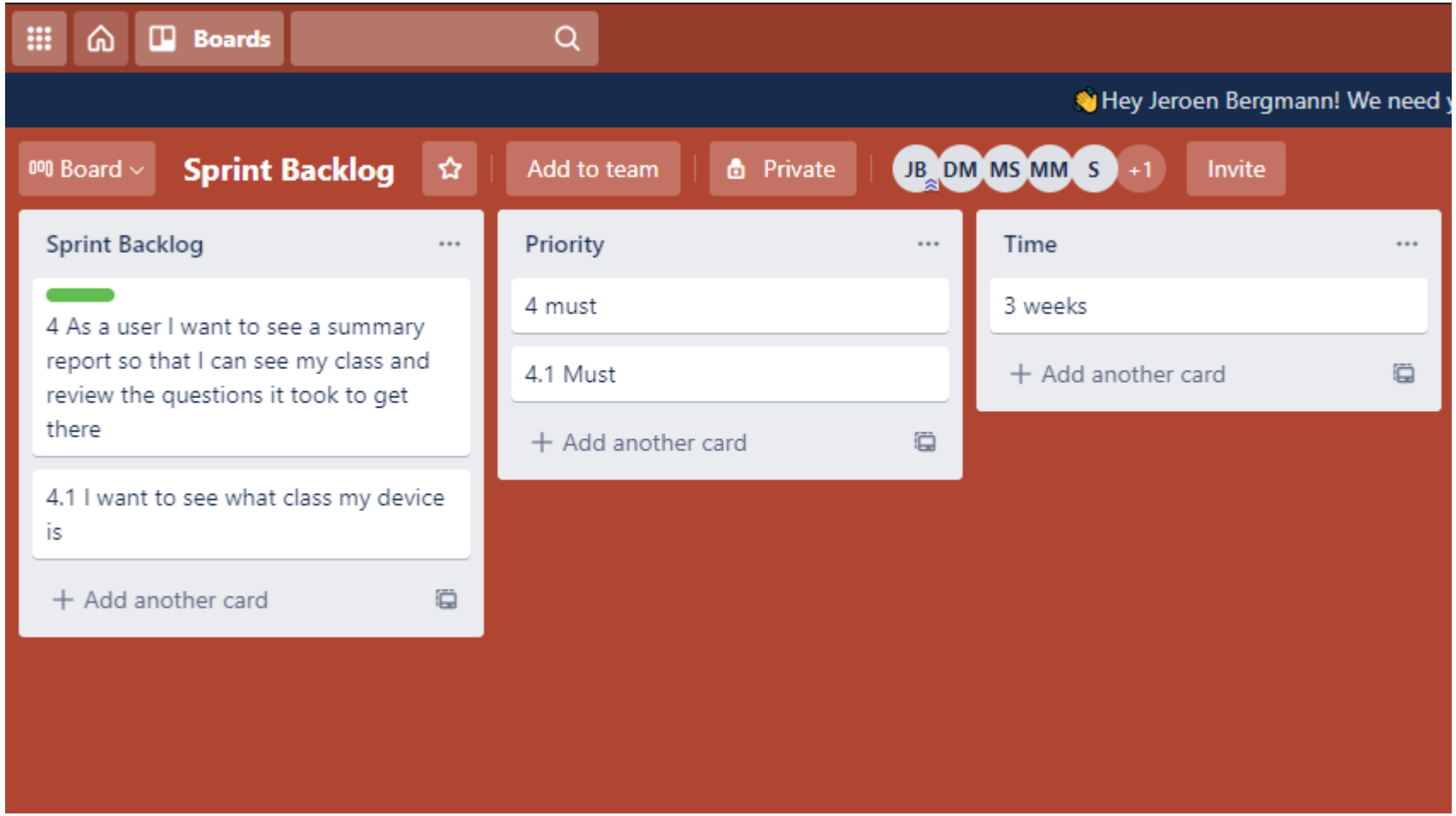
As a user I want to see /need a feature so that solves a requirement



Sprint Backlog (user stories)	Priority	Time
1. As a … I want to see … so that …	**…**	…
1.1.	**…**	…
…		

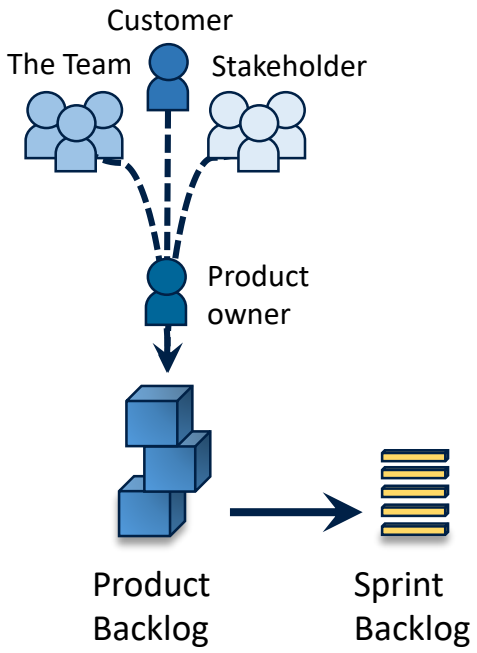
Source: Dr Rita Hendricusdottir

Setup Sprint Backlog (10 mins)



Source: www.trello.com

Agile – Sprint Backlog (1 day, group meeting)



Sprint Backlog	Priority	Time
1. Setup server and database	**Must**	2.5
1.1. The application can be visited on the to-be-agreed url for production	Must	

Sprint Backlog	Priority	Time
2. Style page components based on sketch design	**Must**	2
2.1 Implement components based on brief from designer	Must	

Sprint Backlog	Priority	Time
3. As a user I want to see one question page so that I know which one to answer	**Must**	2
3.1. I want to see a question title	Must	

Sprint Backlog	Priority	Time
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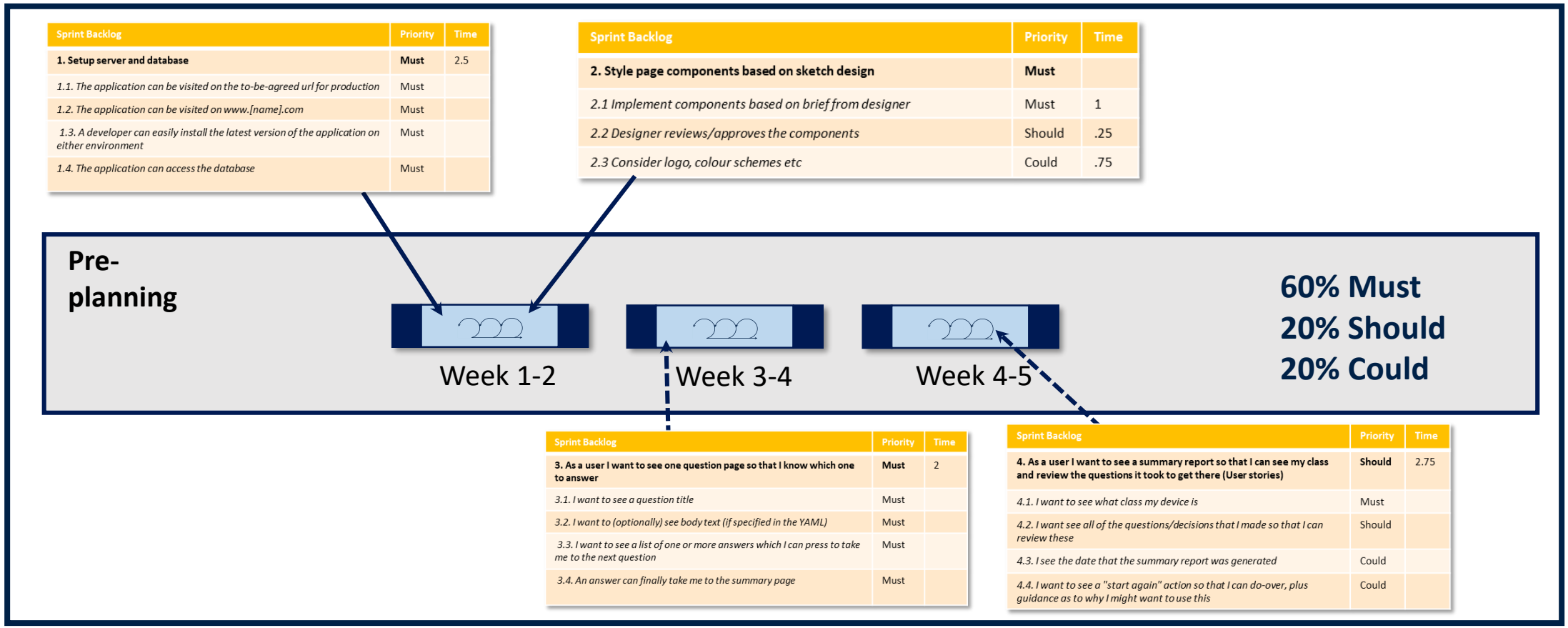
Priority	Time
Must	
Must	
Must	
Must	
Should	
Could	

Source: Dr Rita Hendricusdottir

Agile – Planning the Sprints



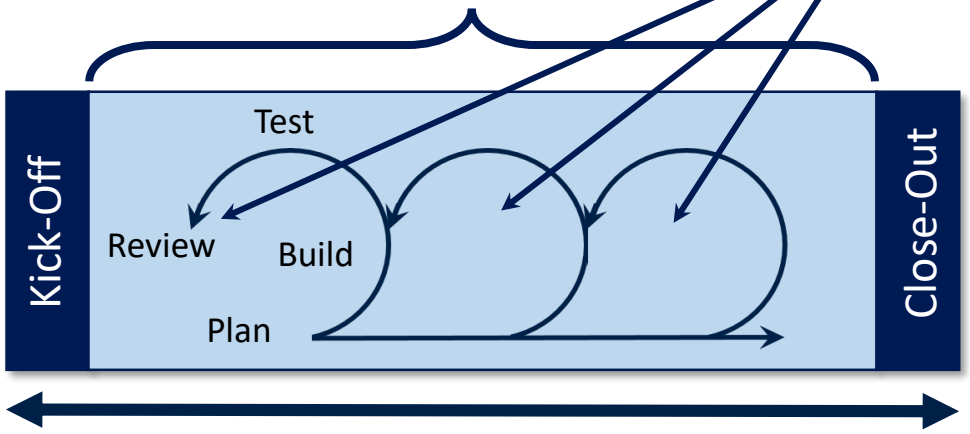
Source: Dr Rita Hendricusdottir

Agile – Time box / Sprint

Daily stand up meetings

- What did you do yesterday
- What are you going to do today
- Any issues?
- 2 minutes p.p

Product Owner / Business Ambassador



Kick-off

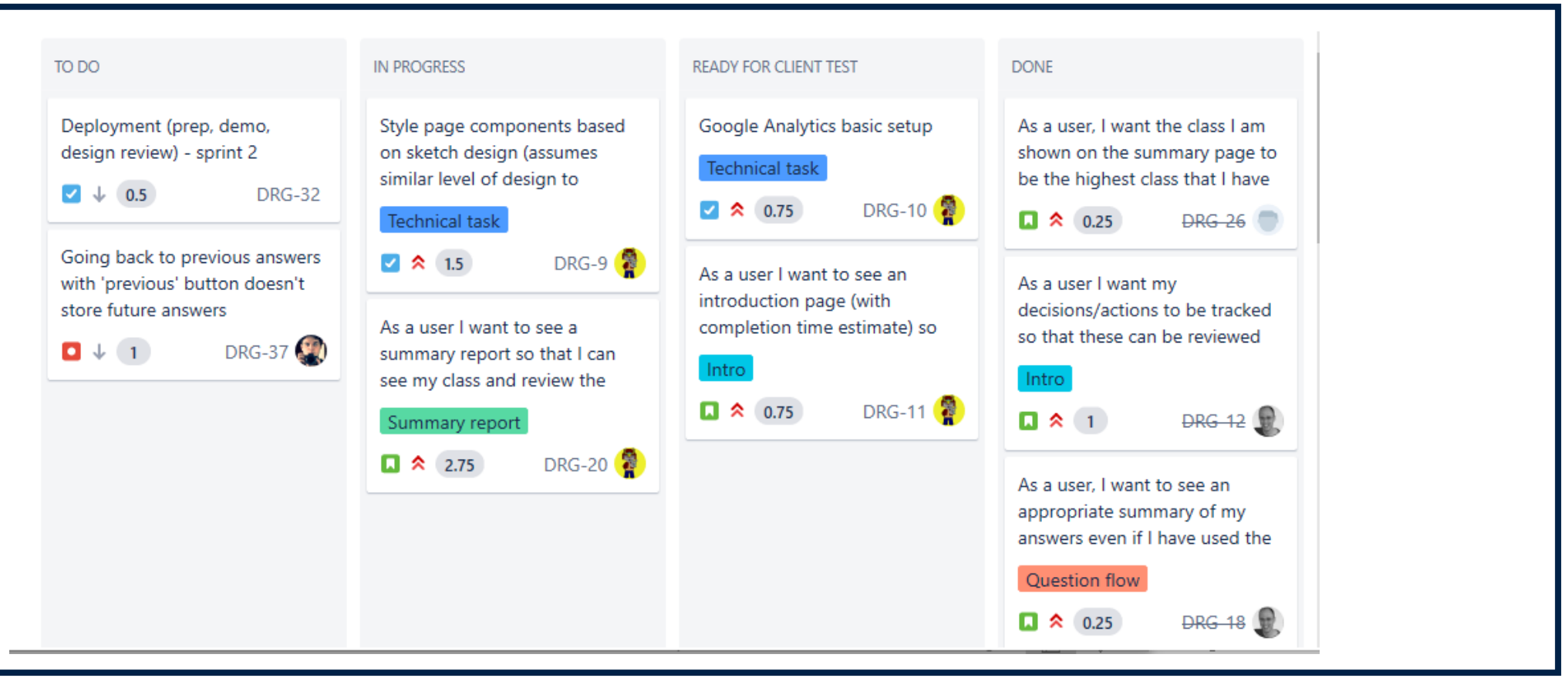
- Plan the Sprint / highlight dependencies
- Agree on the acceptance criteria
- Review availability of team members

Close-Out

- Product Owner signs off the tasks
- Evaluate the prioritisation
- Retrospective

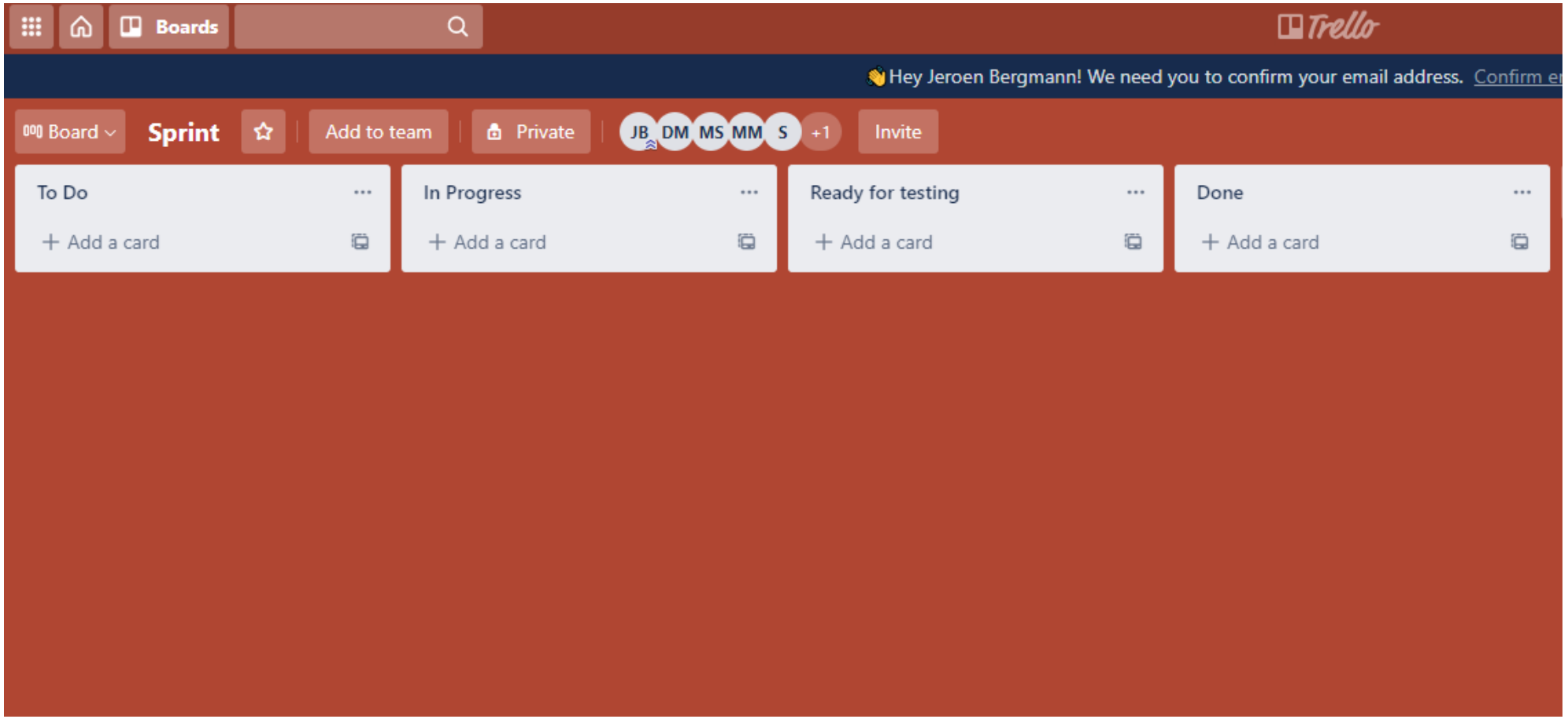
Source: Dr Rita Hendricusdottir

Agile – Sprint: tracking progress



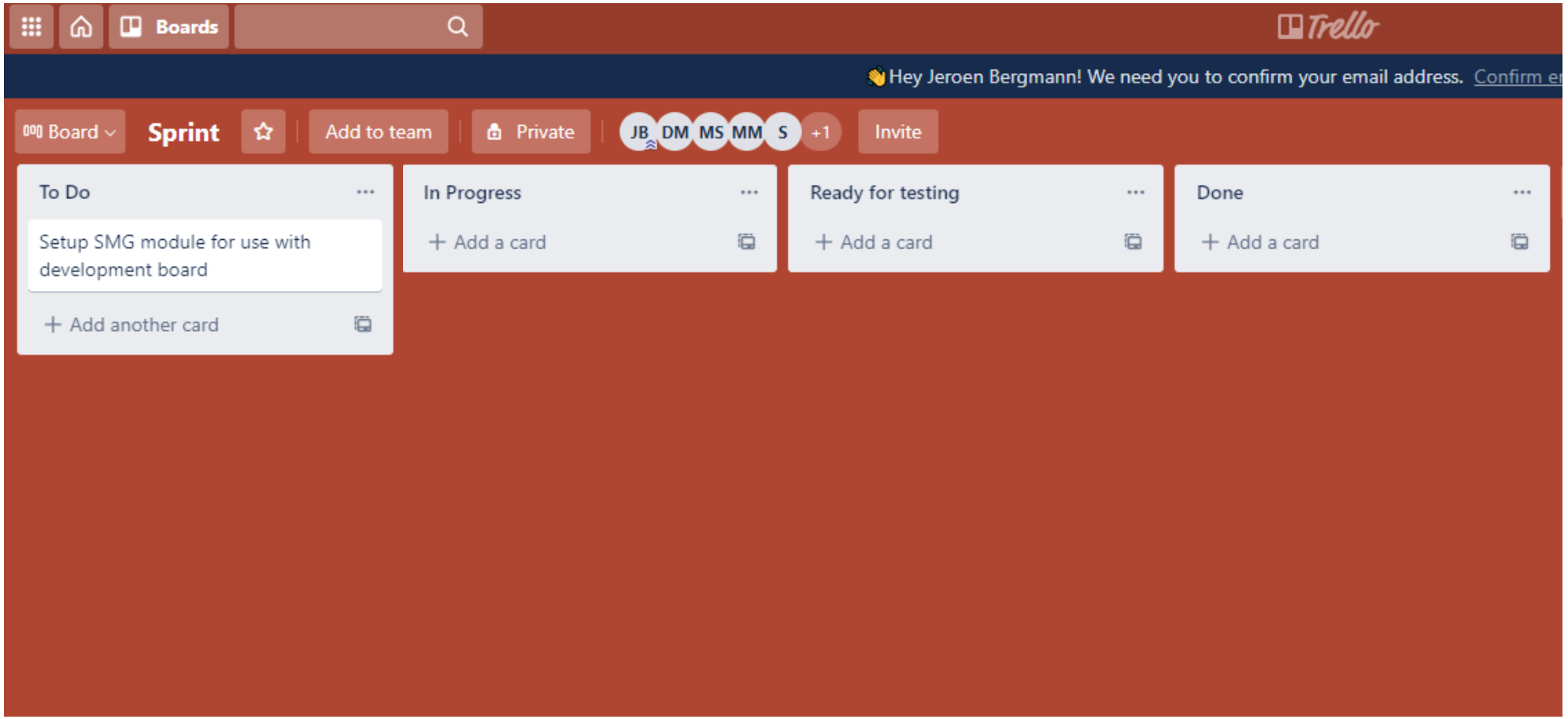
Source: Dr Rita Hendricusdottir

Setup Sprint (10 mins)



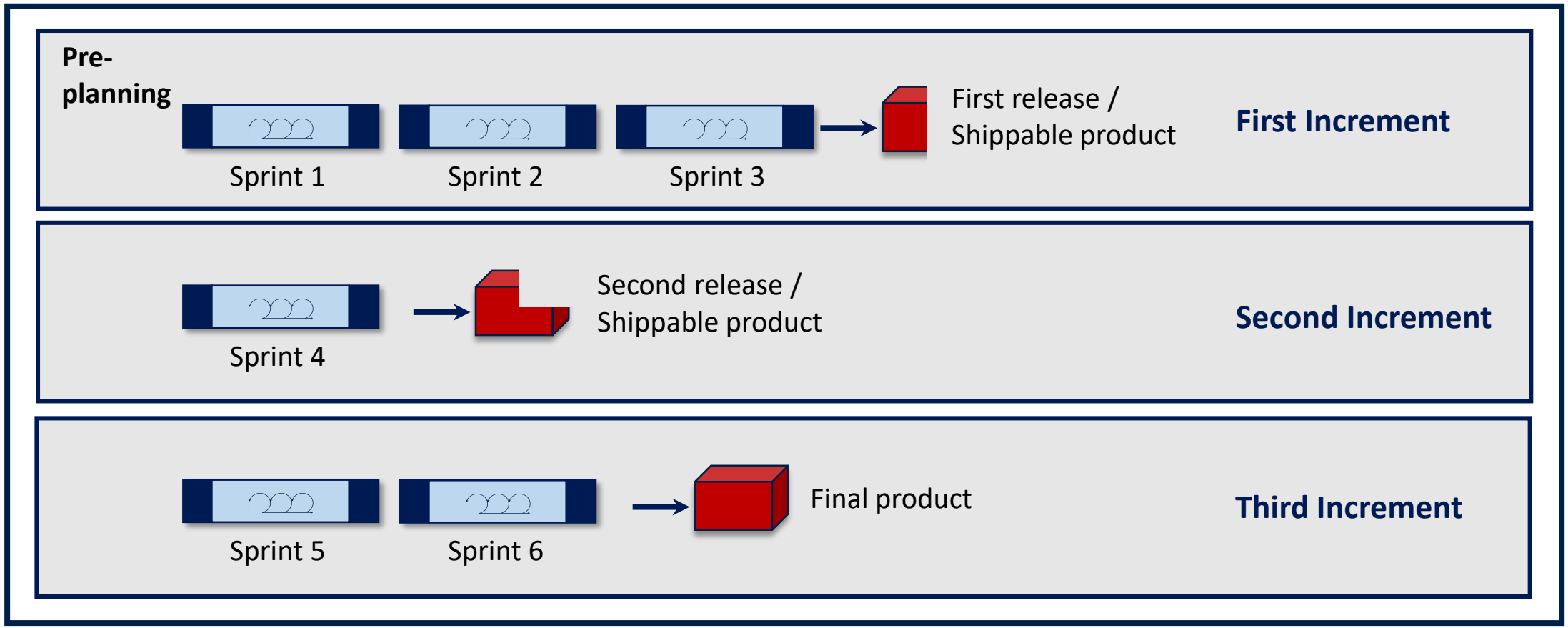
Source: www.trello.com

Setup Sprint – add cards



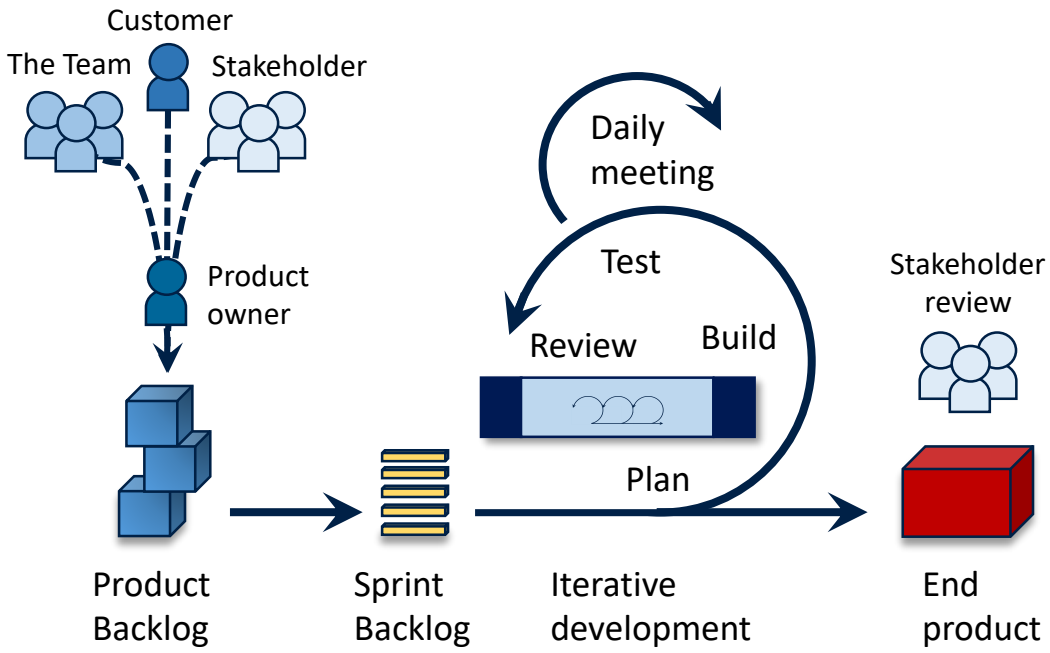
Source: www.trello.com

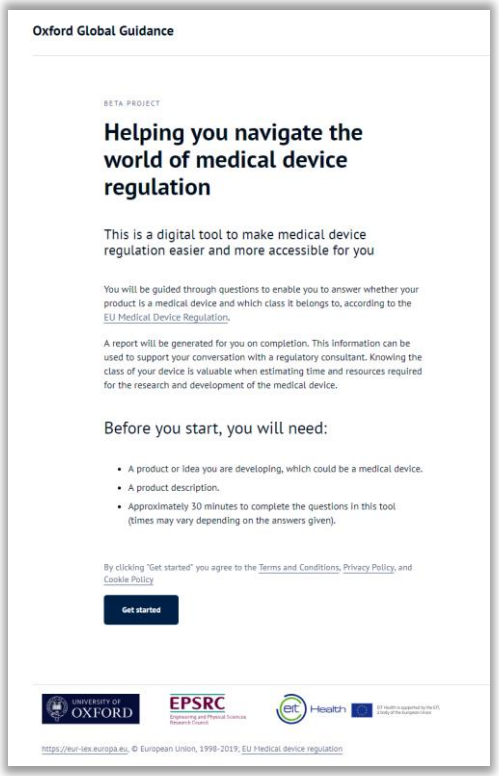
Agile – Iterative Development



Source: Dr Rita Hendricusdottir

Agile – End product




Oxford Global Guidance

BETA PROJECT

Helping you navigate the world of medical device regulation

This is a digital tool to make medical device regulation easier and more accessible for you

You will be guided through questions to enable you to answer whether your product is a medical device and which class it belongs to, according to the EU Medical Device Regulation.

A report will be generated for you on completion. This information can be used to support your conversation with a regulatory consultant. Knowing the class of your device is valuable when estimating time and resources required for the research and development of the medical device.

Before you start, you will need:

- A product or idea you are developing, which could be a medical device.
- A product description.
- Approximately 30 minutes to complete the questions in this tool (times may vary depending on the answers given).

By clicking "Get started" you agree to the Terms and Conditions, Privacy Policy, and Cookie Policy

Get started

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https://eur-lex.europa.eu, © European Union, 1998-2019, EU Medical device regulation

Source: Dr Rita Hendricusdottir

MPiE

Questions?

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Management Practice

11. Scheduling

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

17/11/2020

Course

Literature for the course:

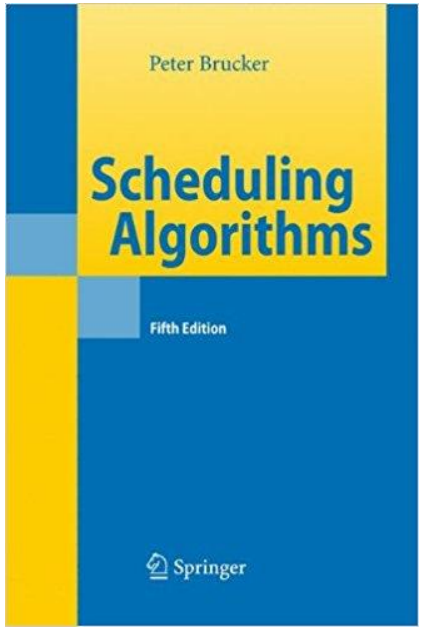
Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Understand scheduling approaches
- Able to solve basic scheduling problems

Literature for this session:

www.springer.com/gb/book/9783540695158



Schedule management definition

- Schedule management is the process of developing, maintaining and communicating schedules for time and resource.

- A schedule is the timetable for a project, programme or portfolio. It shows how the work will progress over a period of time and takes into account factors such as limited resources and estimating uncertainty.

Source: The Chartered Body for the Project Profession (APM)

Schedule

- The scheduling process starts with the work that is needed **to deliver stakeholder requirements**. This includes the technical work that creates outputs, the change management work that delivers benefits, and the management activity that handles aspects, such as risk management and stakeholder management.
- Some types of work can be defined much more easily than other types. The work involved in building a house is clear from the start. The work involved in maintaining a generator is not clear until inspections are complete. Engineering work tends to have complete specifications from the start, whereas change management and some IT work follow a more iterative approach to defining what needs to be done.

Source: The Chartered Body for the Project Profession (APM)

Schedule

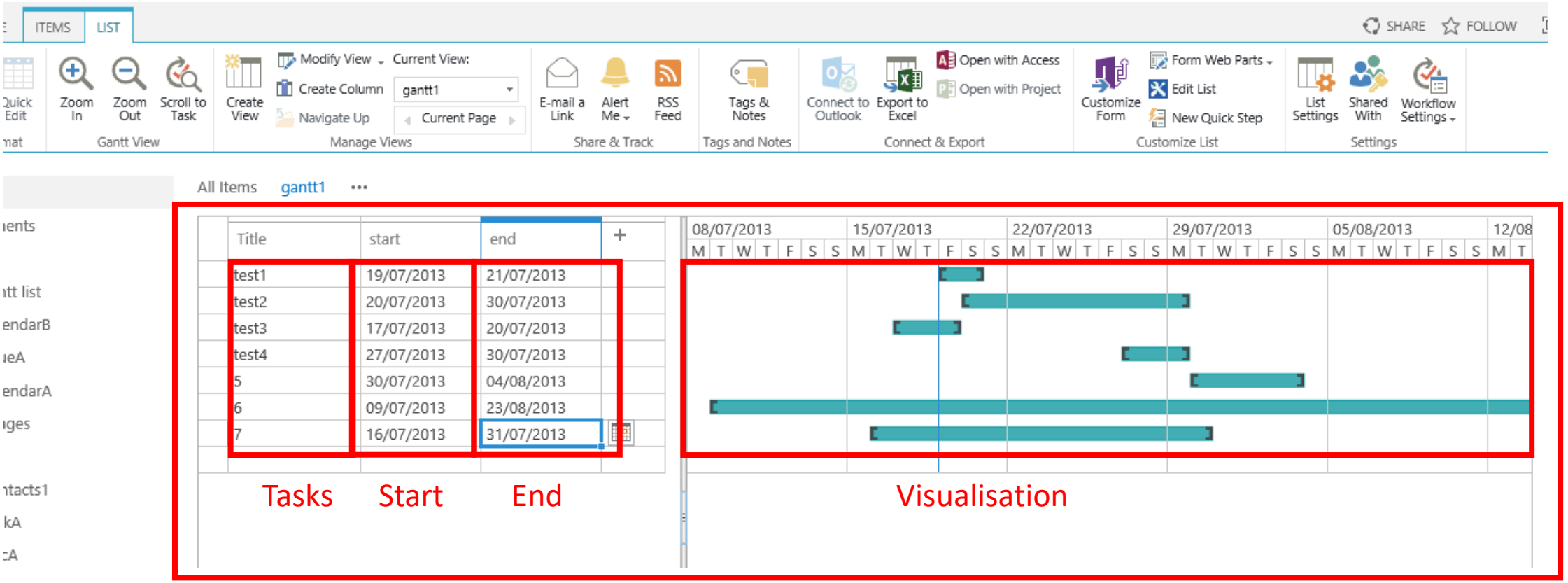
Schedules are presented in many different ways in order to suit the circumstances. The choice of presentation will depend upon:

- the level of detail required;
- whether time and/or resource is being shown;
- the context of the work (e.g. construction, IT, engineering or business change);
- the dimension being scheduled (project, programme or portfolio);
- the target audience.

The most common form of graphical schedule is the Gantt chart. In its simplest form this uses bars on a horizontal timescale to show the start, duration and finish of packages of work.

Source: The Chartered Body for the Project Profession (APM)

Gantt Chart - Recap



Source: Microsoft SharePoint

Example of job scheduling

- Processor scheduling
- Bandwidth scheduling
- Package delivery scheduling
- Patient admission scheduling

Finding the optimal sequence of jobs.

20 jobs on one machine gives 20! (2.43×10^{18})

Let’s look at scheduling again

- Scheduling is the process of organizing, choosing and timing resource usage to carry out all the activities necessary to produce the desired outputs at the desired times, while satisfying a large number of time and relationship constraints among the activities and the resources

Source: Morton and Pentico, 1993

Models in scheduling

- The assessment of ‘scheduling’ as defined by Critical Path Analysis (CPA) is now over 60 year old.
- The field to use algorithms really started in the fifties and then evolved further in the seventies, computer scientists started to use scheduling as a tool for improving the performance of computer systems.

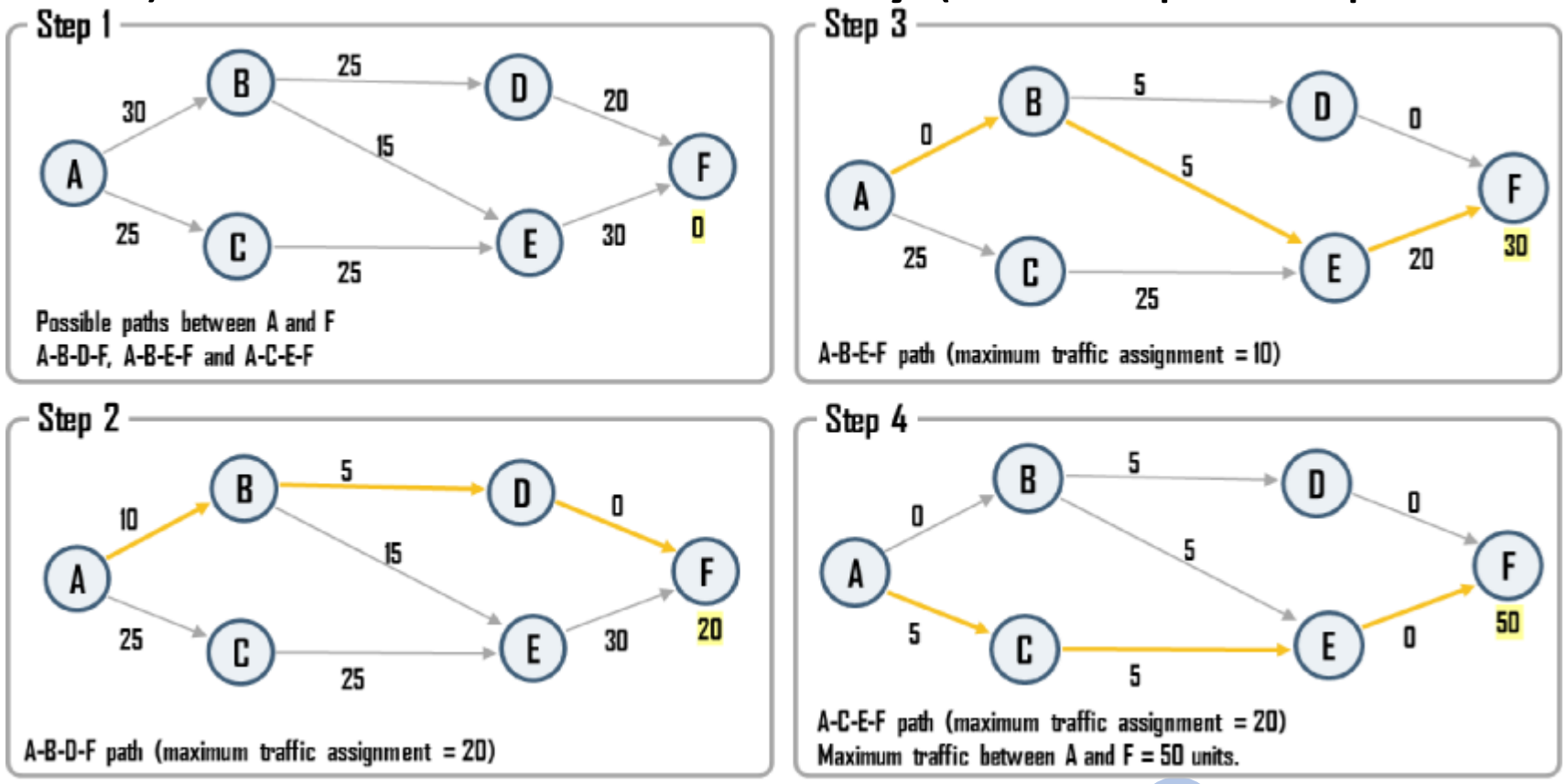
Source: Peter Brucker, Scheduling Algorithms, 2007

Models in scheduling

- **Instance:** Particular set of data for the model
- **Exact algorithm:** Optimum solution for every instance
- **Heuristic algorithm:** an acceptable solution, that is optimal or at least close to optimal for every instance

Heuristic example

- Assigning the maximum possible amount of traffic between two locations (A and F) can be solved **heuristically** (other options possible)

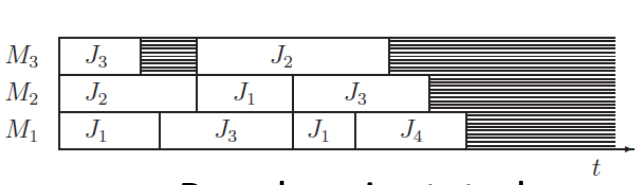


Source: Hofstra University, Geography of transport systems

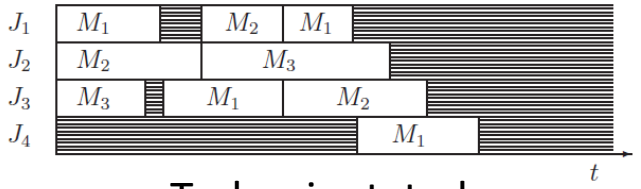
Models in scheduling

- Suppose we have *m* number of Machines or people M_j with *j=1,…,m* who need to process *n* Jobs or tasks J_i *(i=1,…,n)*.

- This allows us to state; a **schedule** is for each job an allocation of one or more time intervals to one or more people.



People orientated



Task orientated

Source: Peter Brucker, Scheduling Algorithms, 2007

Job

- A job J_i consists of a number n_i of operations O_{ij} .
- Associated with operation O_{ij} is a **processing time** p_{ij} , specific for a person/machine (i) and job (j).

$$in\ the\ case\ J_i\ and\ \ n_i = 1 \quad \therefore \ J_i = O_{i1}$$

- If there is only one operation ($n_i = 1$), we then identify J_i with O_{i1} and denote the processing requirement by p_i. The job in this case it the single operation.

- A **release time** r_i, on which the first operation of J_i becomes available for processing may be specified.

Source: Peter Brucker, Scheduling Algorithms, 2007

Schedule is feasible

The schedule is **feasible** if:

(1) No two time intervals overlap on the same machine

(2) No two time intervals allocated to the same job overlap

(3) It meets a number of problem-specific characteristics.

A schedule is **optimal** if it minimizes a given optimality criterion.

Source: Peter Brucker, Scheduling Algorithms, 2007

Optimising the scheduling

- From a management point of view we want to **optimise cost and profit**, but it is hard to directly relate this to the schedule.
- In terms of project management it is essential that the project is **on time**, on budget and up to quality. Time is a leading factor in accomplishing this. The problem is how achieve it.
- A specific measurable outcome can thus be selected against which the schedule is optimised. One suitable candidate is time.
- A cost function $f_i(t)$ can be set which will be minimised for an certain optimality criteria. For example it can be completing J_i at time t.

Source: Peter Brucker, Scheduling Algorithms, 2007; Prince2

Scheduling problems

Classes of scheduling problems are specified in terms of a three-field classification:

- α specifies the **machine environment**
- β specifies the **job characteristics**
- γ denotes the **optimality criterion**

All three need to be specified to define the problem

Source: Graham et al. (1979)

Machine environment (α)

- Single Machine
- Parallel Machines (identical vs. different)
- Flow Shops: different machines (e.g. assembly lines)

– Each job must be processed by each machine exactly once

– All jobs have the same routing (same order)

– A job cannot begin processing on the second machine until it has completed the processing on the first

- Job Shops

– Each job may have its own routing (different routes can be selected)

- Open Shops (e.g. car repair shop)

– Jobs have no specific routing (but will need to be determined)

Machine environment (α)

The following parameters are set

$$\alpha 1 \in \{\circ, P, Q, R, PMPM, QMPM\}$$

If each job can be processed on each of the machines $M_1, \ldots, M_m$ then $\alpha 1 \in \{P, Q, R\}$
Scheduled jobs on machines have a certain flow-time and thus there is a speed (s).
P = identical parallel machines ($p_{ij} = p_i$)
Q = uniform parallel machines ($p_{ij} = \frac{p_i}{s_j}$) with s_j the speed of machine M_j
R = unrelated parallel machines ($p_{ij} = \frac{p_i}{s_{ij}}$) with job-dependent speeds s_{ij} of M_j
PMPM = multi-purpose machines with identical speeds
QMPM = multi-purpose machines with uniform speeds

Source: Peter Brucker, Scheduling Algorithms, 2007

Machine environment – shops

In a problem with **multi-purpose machines** a set of machines μ_j is associated with each job j indicating that j can be processed on one machine in μ_j only.

$$\alpha 1 \in \{G, J, F, O, X\}$$

This is a multi-operation model. Associated with each job J_i there is a set of operations. The machines are dedicated, i.e. all μ_{ij} are one element sets.

G = general shop, there are precedence relations between arbitrary operations.

There are m machines $M_1, \dots, M_m$ and n jobs $j = 1, \dots, n$.

Job j consists of $n(j)$ operations $O_{1j}, O_{2j}, \dots, O_{n(j)j}$ where O_{ij} must be processed for p_{ij} time units on a dedicated machine $\mu_{ij} \in \{M_1, \dots, M_m\}$.

Two operations of the same job **cannot** be processed at the same time. Precedence constraints are given between the operations.

Source: Peter Brucker, Scheduling Algorithms, 2007

Machine environment – shops – cont'd

$\alpha 1 \in \{G, J, F, O, X\}$

A→B indicates A must be completed before B start

J = Job-shop problem. It is a general shop scheduling problem with chain precedence constraints of the form $O_{1j} \rightarrow O_{2j} \rightarrow \ldots \rightarrow O_{n(j)j}$

F = Flow-shop problem. It is a special job-shop problem with $n(j) = m$ operations for $j = 1, \ldots, n$ and $\mu_{ij} = M_i$ for $i = 1, \ldots, m$ and $j = 1, \ldots, n$

O = Open shop is same as flow shop, but there are no precedence relations between the operations.

X = Mixed shop is a combination of a job shop and an open shop

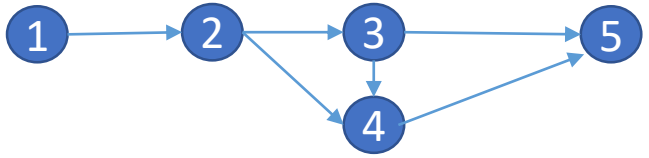
Source: Peter Brucker, Scheduling Algorithms, 2007

Job characteristics (β)

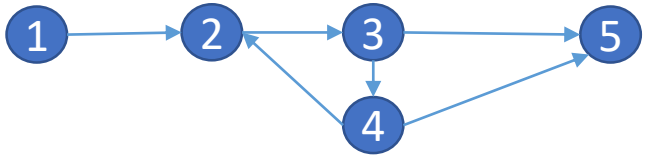
$\beta = \circ$

β_1 = pre-emption or job splitting (process interruption allowed)

β_2 = description of precedence relations (e.g. acyclic directed graph)



acyclic graph



cyclic graph

β_3 = release times (r_i) specified for each job

β_4 = specifies restrictions on the processing times or on the number of operations

β_5 = specifies if deadlines (d_i) are set for each J_i

β_6 = specifies if it is a p-batch or s-batch

β_6

- A batch is a set of jobs that can be processed jointly.
- The completion time of all the jobs in a batch is the finishing time of the last job in the batch.
- In the p-batch set of problems, the length of a batch is defined as the **maximum** processing time of any job in the batch.
- The s-batch set of problems has a different definition for the length of a batch, namely, it is partitioned into a **setup time** and the **sum of the processing times of the** jobs in the batch.

Source: J. Diaz et al. . (2006)

Optimality criteria

C_i is the finishing time of job J_i and $f_i(C_i)$ is the associated cost

Types of total cost functions

$$f_{max}(C) := max\{f_i(C_i)|i = 1, \dots, n\}$$ **Bottleneck** objectives

and

$$\sum f_i(C) = \sum_{i=1}^{i=n} f_i(C_i)$$ **Sum** objectives

Optimality criteria

C_i = The completion time of job J_i	$C_i \neq p_i \ \forall \ i=2:n$
F_i = The flow time of job J_i	$C_i - r_i$
L_i = Lateness of job J_i	$C_i - d_i$
T_i = Tardiness of job J_i	$max\{0, L_i\}$
E_i = Earliness of job J_i	$max\{0, -L_i\}$

$\delta_i = 1$ if job i is tardy ($T_i > 0$)

$\delta_i = 0$ if job i is in time ($T_i = 0$)

$C_{max} = Max_{i=1:n}\{C_i\}$	Makespan
$L_{max} = Max_{i=1:n}\{L_i\}$	Maximum lateness
$T_{max} = Max_{i=1:n}\{T_i\}$	Maximum tardiness

Flow and job shop

- A flow shop is an arrangement of machines, such that all the jobs visit machines in the order in which they are arranged. This is applicable to a scheduling system **where all jobs are required to visit all the machines in the same order**.

- A job shop scheduling problem is one **where each job has its own set of machines** that it visits in a given order. This is different from a flow shop where all the jobs visit all the machines in the same order.

Example – 4 jobs 3 person job shop problem

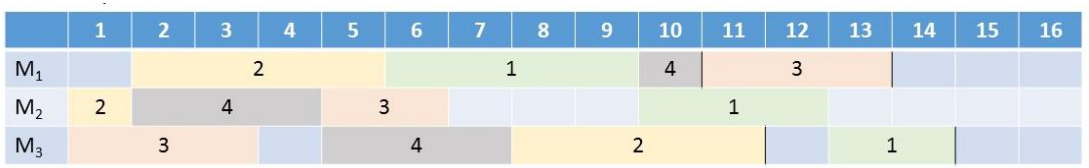
Project A					
Job number (i)	Operation (O_1)	Operation (O_2)	Operation (O_3)	Release date (r_i)	Deadline (d_i)
1	$P_{11} = 4$	$P_{12} = 3$	$P_{13} = 2$	0	16
2	$P_{22} = 1$	$P_{21} = 4$	$P_{23} = 4$	0	14
3	$P_{33} = 3$	$P_{32} = 2$	$P_{31} = 3$	0	10
4	$P_{42} = 3$	$P_{43} = 3$	$P_{41} = 1$	0	8

P_{ik} = Time to process job i by person k

Given sequence

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
M_1		2				1				4	3					
M_2	2		4		3					1						
M_3		3			4			2					1			

Outcome of scheduling



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
M_1		2				1				4	3					
M_2	2	4			3					1						
M_3	3				4			2					1			

Makespan (maximum completion time)

$$C_{max} = Max_{i=1:n}\{C_i\} = Max\{C_1, C_2, C_3, C_4\} = Max\{14,11,13,10\} = 14$$

Total flow time

$$\sum F_i = \sum C_i - r_i = 14 + 11 + 13 + 10 = 48$$

Total lateness $[L_i=C_i-d_i]$

$$\sum L_i = (14 - 16) + (11 - 14) + (13 - 10) + (10 - 8) = 0$$

Total tardiness $[max\{0, L_i\}] \mid L_i > 0$

$$\sum T_i = max\{3,2,0,0\} = 3$$

2δ = 2 tardy jobs (J_4, J_3)

Some basic sequencing rules

- **FCFS (First Come First Served)** Jobs processed in the order they come to the shop

  J_i is in order i
- **SPT (Shortest Processing Time)** Jobs with the shortest processing time are scheduled first

  $J_{[x, y, \ldots n]}$ is in order $p_x \leq p_y \leq \ldots p_n$
- **EDD (Earliest Due Date or Deadline)** Jobs are sequenced according to their due dates

  $J_{[x, y, \ldots n]}$ is in order $d_x \leq d_y \leq \ldots d_n$
- **CR (Critical Ratio)** Compute the ratio of processing time of the job and remaining time until the due date. Schedule the job with the smallest CR value next.

$$CR_i = \frac{d_i - CT_i}{p_i}$$

Current time (CT_i) is $\sum p_j$ with j representing the index of all selected p in the sequence

Source: R Lindeke, 2005

SPT proof - single machine

Shortest processing time, so we look at completion time in terms of processing time.

$$[C_1, C_2, \dots C_n] = [p_1, (p_1 + p_2), \dots, (p_1 + \cdots + p_n)]$$

$$\sum_{i=1}^{n} (n - i + 1) p_i$$

$(n - i + 1)$ ↓

p_i ↑

Aim to obtain minimum $\sum C_i$

x	y(i:n)	y(n:i)	Prod x & y(i:n)	Prod x & y(n:i)
1	1	10	1	10
2	2	9	4	18
3	3	8	9	24
4	4	7	16	28
5	5	6	25	30
6	6	5	36	30
7	7	4	49	28
8	8	3	64	24
9	9	2	81	18
10	10	1	100	10
			∑ 385	220

Single machine scheduling

i	1	2	3	4	5	6
p_i	20	13	39	41	3	1
d_i	70	81	55	21	23	30
r_i	0	0	0	0	0	0

	FCFS	SPT	EDD	CR
$F_{avg} = \frac{\sum_1^n C_i - r_i}{n}$	78.5	42	72.5	72.2
$L_{avg} = \frac{\sum_1^n C_i - di}{n}$	31.8	-4.6	25.8	25.5
# tardy jobs	4	2	6	6

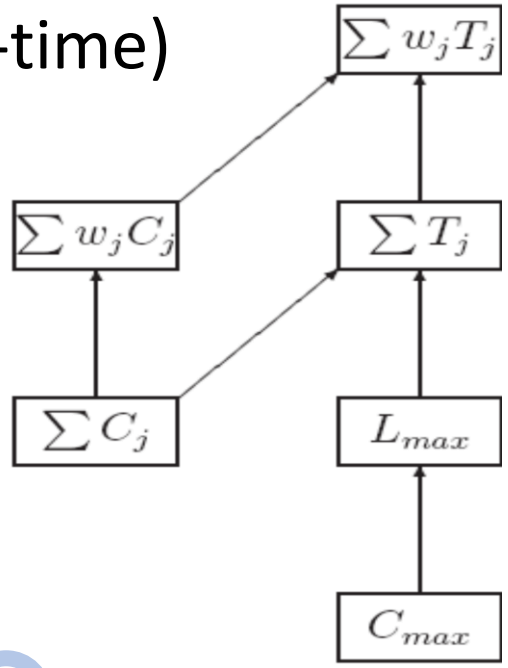
- SPT will guarantee minimum Mean Flow time
- Minimize Maximum lateness with SPT model in this case

Single machine stochastic scheduling

- Assume that p_i (processing times) are random variables and the objective is to minimize average weighted flow time, jobs are sequenced according to expected weighted SPT.
- $\Sigma\ C_j$ (mean flow-time) becomes $\Sigma\ \omega_j C_j$ (weighted flow-time)
- $\Sigma\ \omega_j T_j$ (weighted sum of tardiness)

where the tardiness of job j is given by

$$T_j = max\ \{ 0, C_j - d_j \}.$$



Questions?

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Management Practice

12. Scheduling in a global context

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

17/11/2020

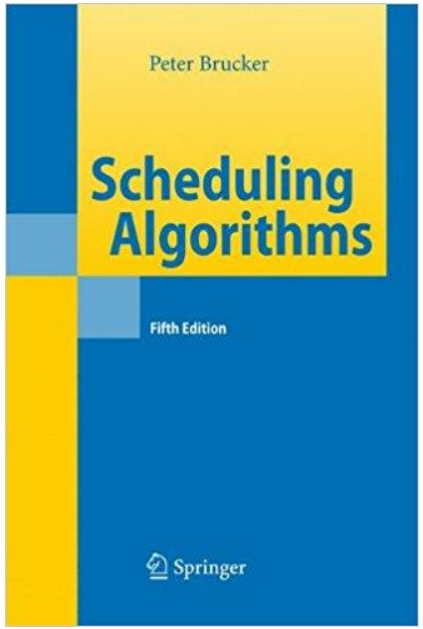
Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to describe preceding constraints
- Able to apply Lawler's Algorithm
- Able to explain aggregation and constraints in global context
- Understand Hofstede's model
- Explain the global value chain
- Understand barriers ad inhibitors in global context



Literature for this session:

www.springer.com/gb/book/9783540695158

Optimality criteria and cost

For example

- Single machine (1), where
- subject to precedence constraints
- the maximum cost for late jobs should be minimized (h_{max})

We denote this problem as $1|\text{Prec}|\ h_{max}$

$h_j(C_j)$ is the cost for completing job j at time C_j, so we could get

$$h_j(C_j) = C_j - d_j$$

Lawler's Algorithm

- $O_{1j} \rightarrow O_{2j} \rightarrow \ldots \rightarrow O_{n(j)j}$ for Precedence Constraints

- The algorithm is applicable for single machine problems with the objective of minimizing
  - Makespan
  - Maximum lateness
  - Maximum tardiness

- It schedules a set of simultaneously arriving tasks on one machine with precedence constraints to minimize maximum tardiness or lateness.

Lawler’s Algorithm

- **General scheme:** The algorithm first assigns a job to the last position, then a job to the position next to last, and so on.
- **Candidate job for a position:** Due to precedence constraints, not all the jobs are candidates for a position. For example, if a job has a successor, the job cannot be assigned to the last position. Hence, candidates for the last position are the ones without any successor.
- **Lawler’s proof** - single machine, can be given by contradiction
- In short, Lawler’s algorithm minimizes e.g. the maximum flow time subject to precedence constraints.

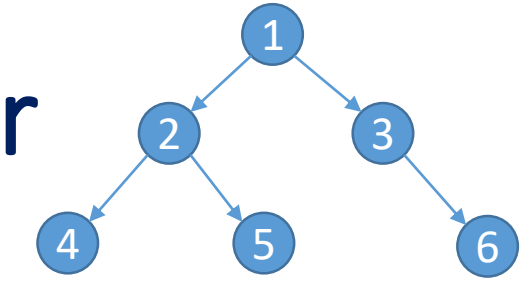
Lawler's Algorithm

- A set of simultaneously arriving jobs on one machine needs to be scheduled with precedence constraints to minimize maximum lateness (or tardiness).

$$L_i=C_i-d_i$$

- At each step a selection is made from the jobs that are not required to precede any other unscheduled job. The job is selected that achieves $min(h_j)= min(F_j-d_j)$

Single machine scheduling - Lawler



	i	1	2	3	4	5	6
	p_i	1	1	1	1	1	1
	d_i	2	5	3	4	5	6
	r_i	0	0	0	0	0	0
	$CMax_a$				6	6	6
	F_a				6	6	6
h_a	L_a				2	1	0

C_{max}=6 ; available jobs {4,5,6}; find min(h); update; repeat

Scheduling

- The main objective of the scheduling is typically reducing the project's **cost and duration**.

- The numerous possible assignments of tasks to the team members and the dependencies between tasks make task scheduling an **NP-hard** problem.

Source: DOI: 10.1109/ICSE-SEIP.2017.30

NP-Hard

- A minimal requirement for an algorithm to be considered “efficient” is that its running time is polynomial: $PT(n^c)$ for some constant c, where n is the size of the input and PT represents the Polynomial time.

- Researchers recognized early on that not all problems can be solved this quickly, but had a hard time figuring out exactly, which ones could and which ones couldn’t.

- There are several so-called ***NP-hard*** problems, which most people believe *cannot* be solved in polynomial time, even though nobody can prove a super-polynomial lower bound.

Source: Alan Cobham,1965; Jeff Erickson 2014

Scheduling

- Problems which are NP-hard cannot be solved efficiently using heuristics and devising efficient algorithms to approximate the optimal solution.

- A set or property of computational decision problems solvable by a **nondeterministic** Turing Machine in a number of steps that is a **polynomial** function of the size of the input. The word "**nondeterministic**" suggests a method of generating potential solutions using some form of nondeterminism or "trial and error"

- Trade optimality, completeness, accuracy or precision to increase the speed and thus competitive advantage.

Source: foldoc.org

Decision problem

- A *decision problem* is a problem whose output is a single Boolean value: Yes or No.
- There are three common classes of decision problems:
- ***P*** is the set of decision problems that can be solved in polynomial time. Intuitively, P is the set of problems that can be solved quickly. *n=5*

Polynomial	**Non-Polynomial**
PT (1)=1	*PT* (2^n)=32
PT (n)=5	*PT (n!)*=120
PT (n^2)=25	*PT* (n^n)=3125

- ***NP*** is the set of decision problems with the following property: If the answer is Yes, then there is a *proof* of this fact that can be checked in polynomial time. Intuitively, NP is the set of decision problems where we can verify a **Yes** answer quickly if we have the solution in front of us.
- ***co-NP*** is essentially the opposite of NP. If the answer to a problem in co-NP is **No**, then there is a proof of this fact that can be checked in polynomial time.

Source: Jeff Erickson 2014

Scheduling in the global context

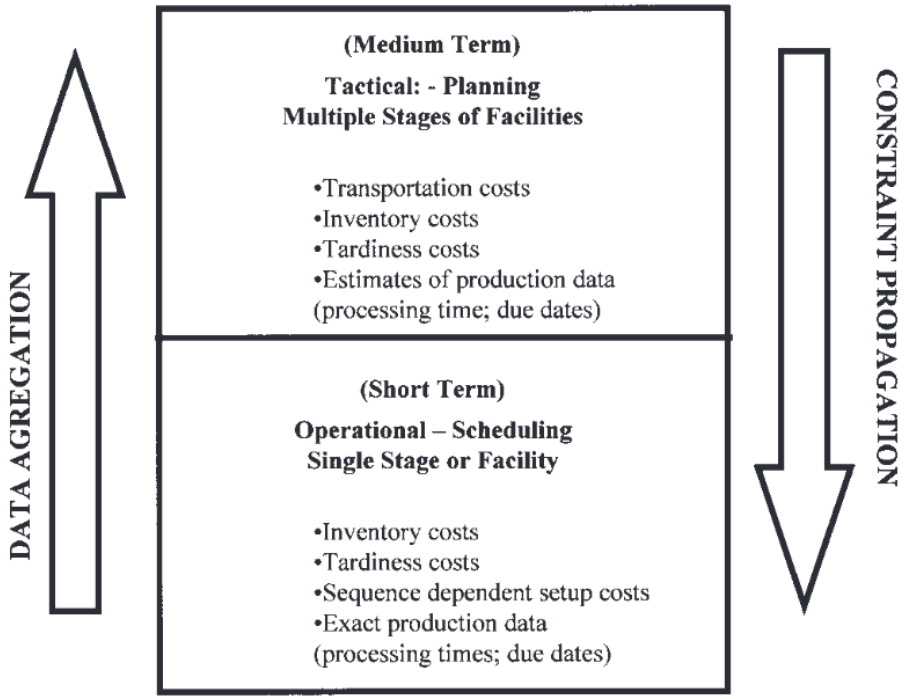
In these case the scheduling can be further influenced by differences in e.g.:

- Regulations
- Social, economical, political and cultural difference
- Fluctuations in exchange rates
- Time zones
- …

- The global nature of business provide further possibilities in terms of assignments and dependencies.

Global supply chain

- Data Aggregation and Constraint Propagation



Source: Kreipl and Pinedo, 2004

Global supply chain

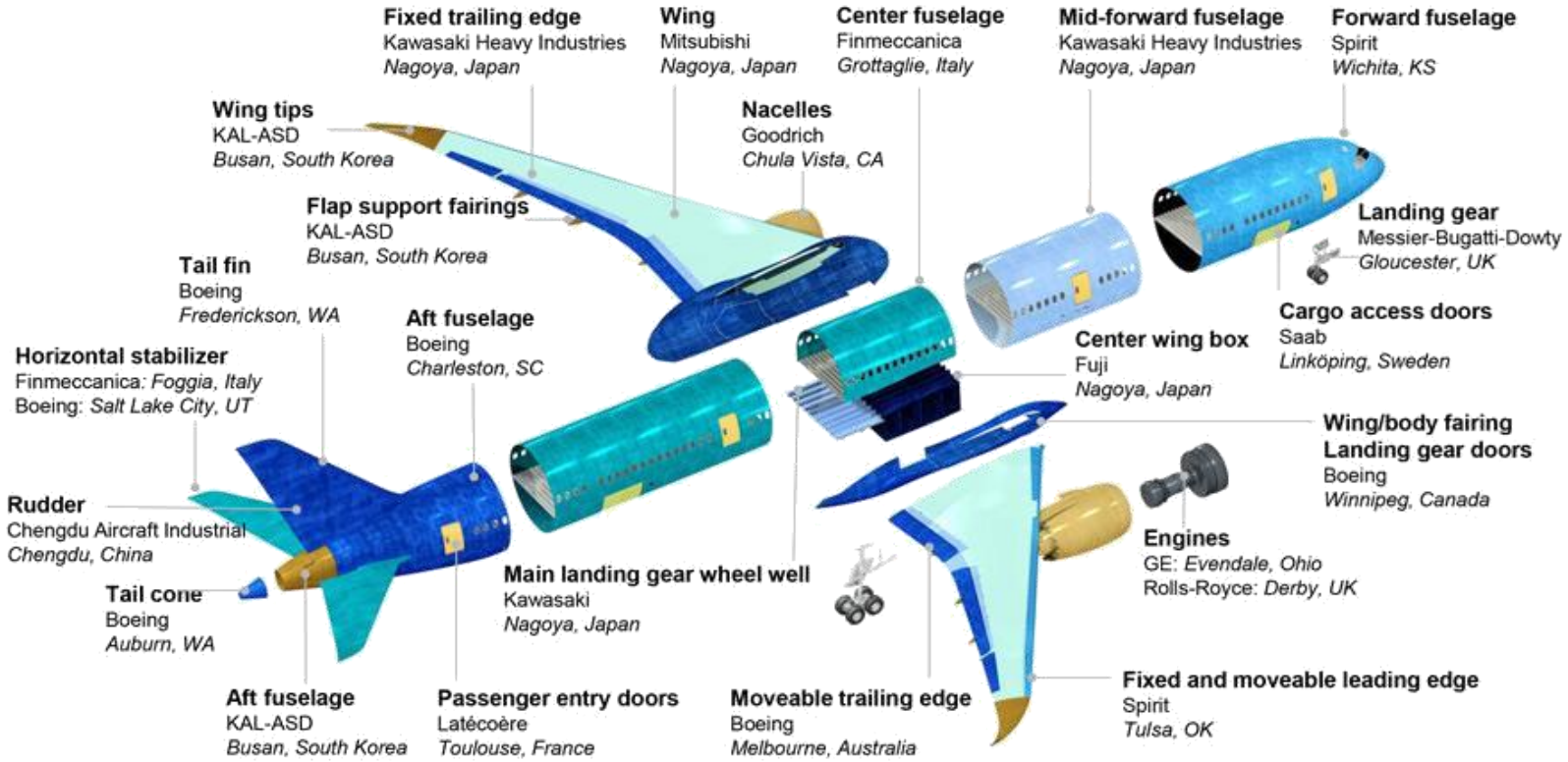
The output of the medium term planning process is an input to the detailed (short term) scheduling process. The scheduling phase of the optimization process is partitioned according to:

- *The different stages and facilities*
- *The different time periods*

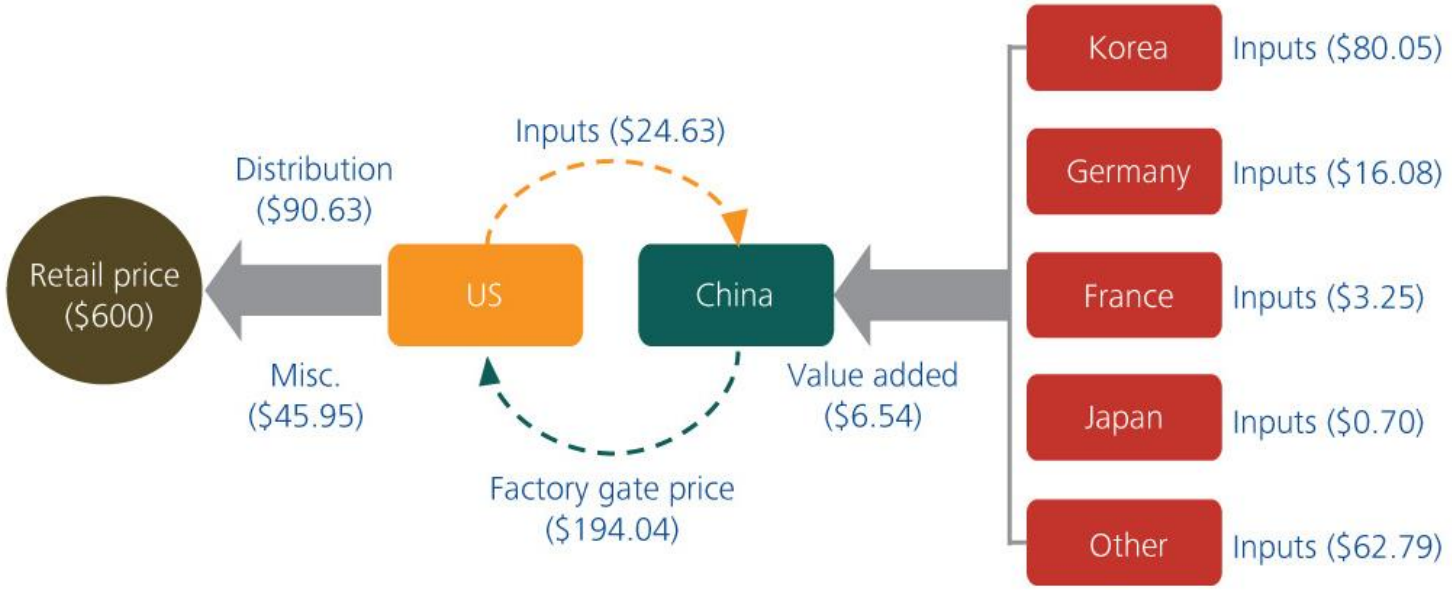
So, in each detailed scheduling problem the scope is considerably narrower (with regard to time as well as space), but the level of detail taken into consideration is considerably higher. This level of detail is increased in the following dimensions:

- The time is measured in a smaller unit (e.g., days or hours); the process may be even time continuous
- The horizon is shorter
- The product demand is more precisely defined
- The facility is not a single entity, but a collection of resources or machines.

Global supply chain



Global value creation for Apple iPhone 4



* Apple is a trademark of Apple Inc., registered in the United States and other countries. "Global value chains: More development strategy than process" is an independent publication and has not been authorized, sponsored, or otherwise approved by Apple Inc.

Source: Organization for Economic Cooperation and Development, "Global value chains: Preliminary evidence and policy issues," March 2011, http://unstats.un.org/unsd/trade/globalforum/publications/gvc/n%20-%20OECD%20-%202011%20-%20GVCs%20-%20Preliminary%20Evidence%20-%20Policy%20Issues_March%204.pdf; Deloitte Services LP economic analysis.

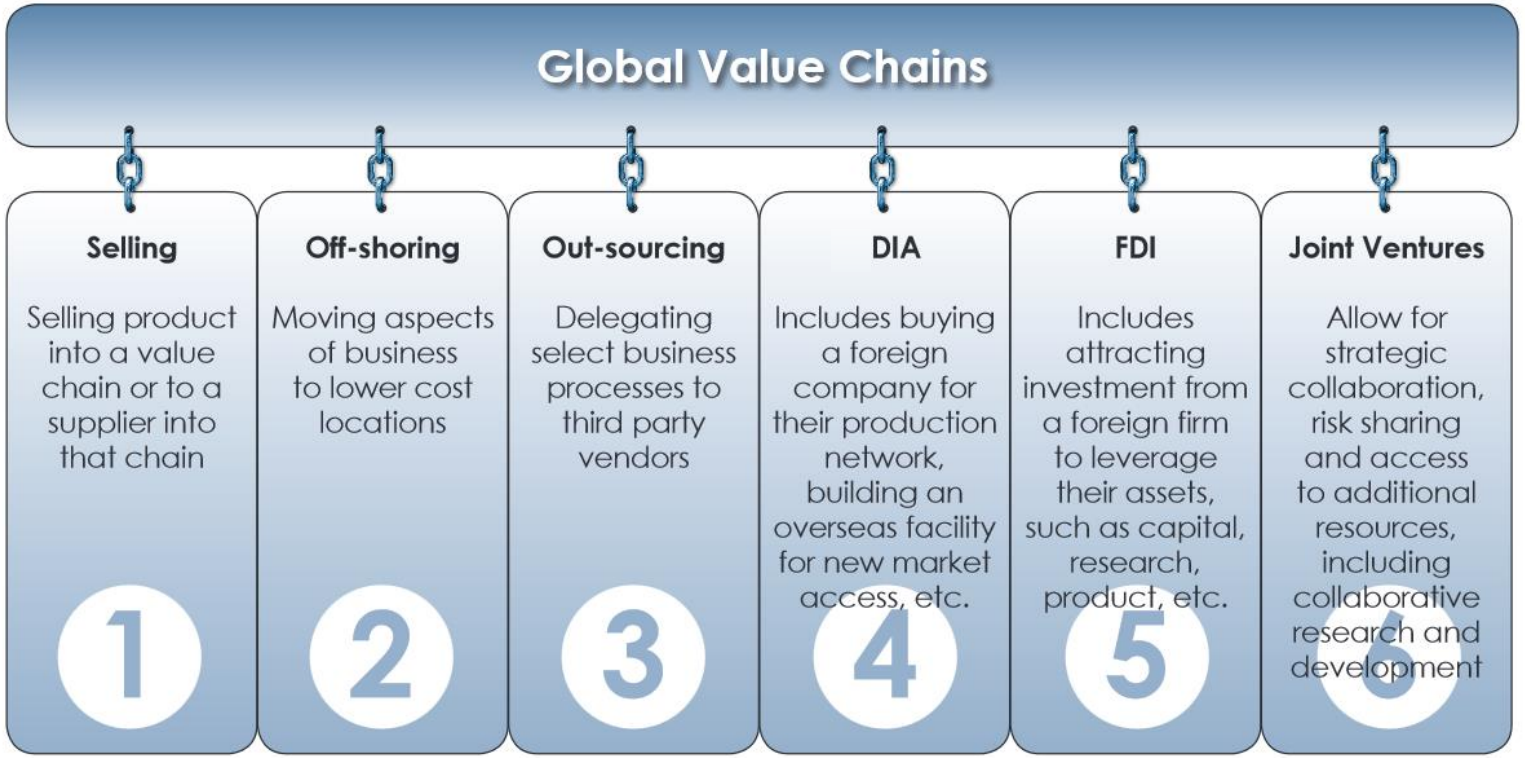
Graphic: Deloitte University Press | DUPress.com

Value chains in the global context

- Imports are increasingly a key complement of local production for many economies .
- Since 2000, WTO trade figures in East Asia show that intermediate goods have comprised over 50% of exports and over 60% of imports in Asia.
- That is also why it is important to measure trade in **value added** terms, rather than just looking at the gross figures. We need to know what **each company in each economy contributes to** production at **each stage of the supply chain**.

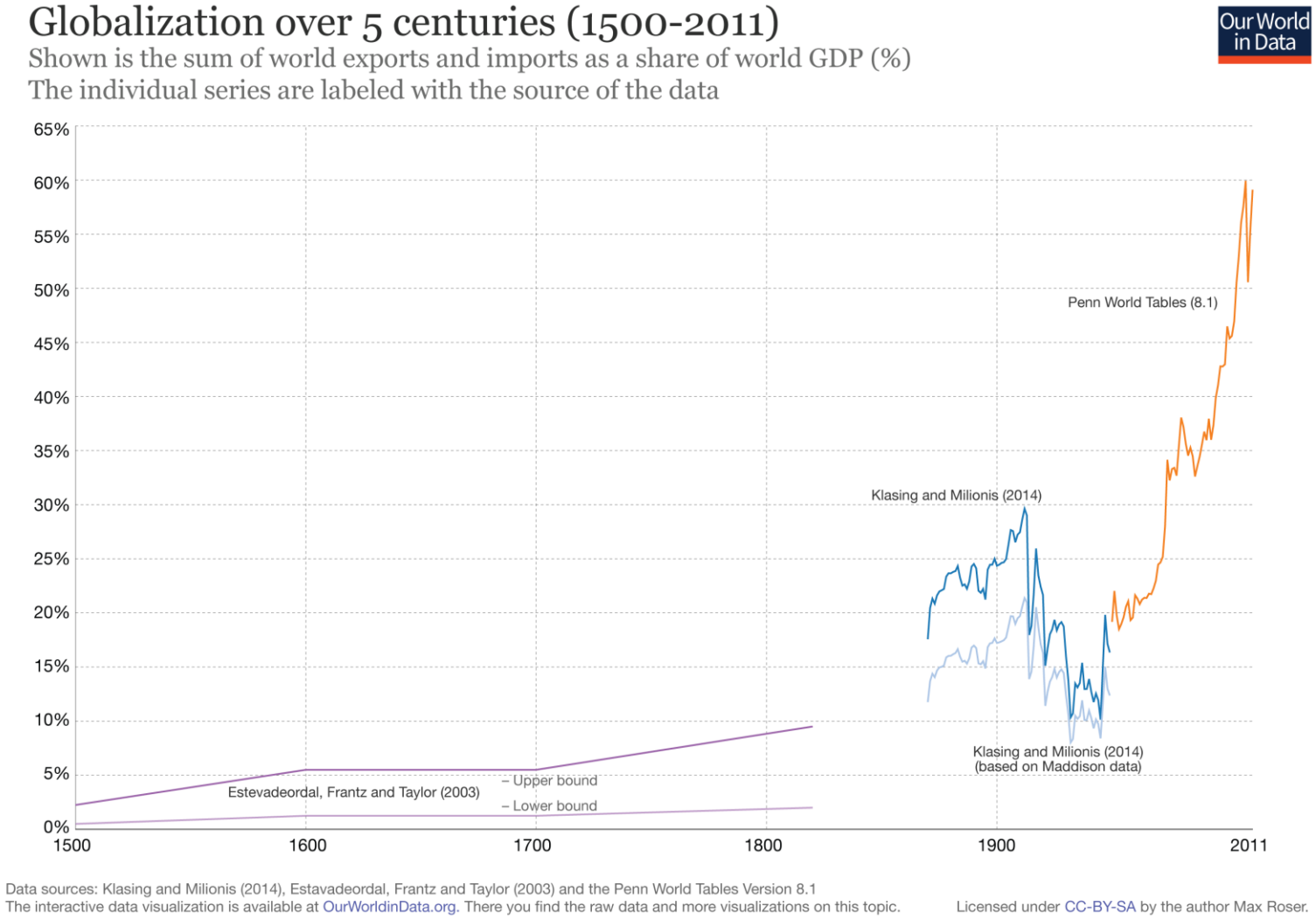
Source: ISBN: 978-92-870-3882-1

Global value chain



Source: The Canadian Trade Commissioner Service 2010

Trade costs and globalization



Data sources: Klasing and Milionis (2014), Estavadeordal, Frantz and Taylor (2003) and the Penn World Tables Version 8.1
The interactive data visualization is available at OurWorldinData.org. There you find the raw data and more visualizations on this topic.

ICT and globalisation

- Coordinating production requires a complex exchange among stages of goods, technology, people, training, investment and information.
- Some of the coordination costs are related to communication, which became easier in the mid-1980s with the global integration of ICT.
- The ICT revolution made it possible to coordinate complexity at distance and across the globe
- The vast wage differences between low-/middle- and high-income countries made separation profitable

Source: ISBN: 978-92-870-3882-1

Network economics

- Today's business environment has been fundamentally transformed as a result of the world's recent evolution into the **information age**, along with the advent of the global economy.
- The modern information age has led to competition based on the mastery of ideas and technology, which is not restricted by geography and which is governed by new **network economics**.
- Research in network economics has addressed two distinct, though strictly related, issues:

(i) How **network structures affect** the behaviour of social and economic actors

(ii) What incentives agents face in forming the network by means of link creation and deletion.

- An actor can be defined as the **source of an action** regardless of its status as a human or non-human
- Agents are so called because they have agency, which means a thing or person that acts to produce a particular result

Source: Aggarwal, 1999; Johnson, 2004

Network economics

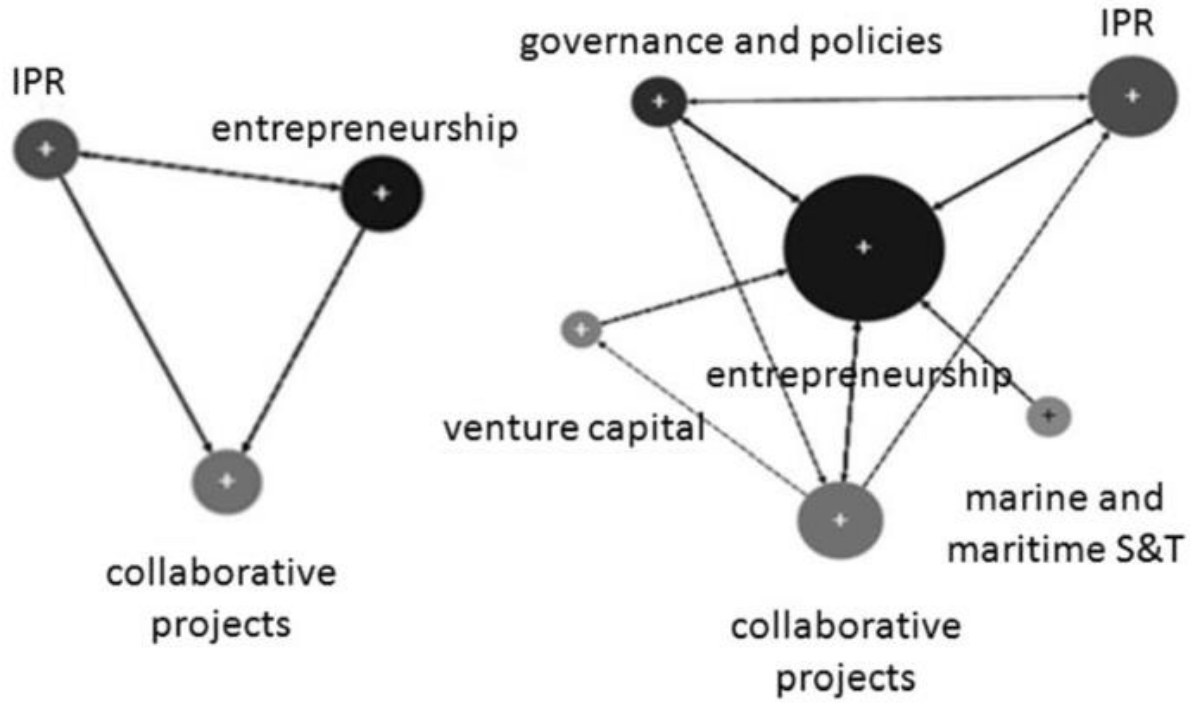
- Recent research has shown how explicitly modelling the network structure of social and economic relations can provide significant theoretical insights, as well as account for previously unexplained empirical observations.
- Relevant areas of application range from labour markets (Calvo-Armentgol, 2004; Jackson and Calvo-Armengol, 2004), trade and financial markets (Eliott, Golub and Jackson, 2013), and R&D collaborations (Goyal and Moraga Gonzales, 2001).

Source: Johnson, 2004

Actor-network example

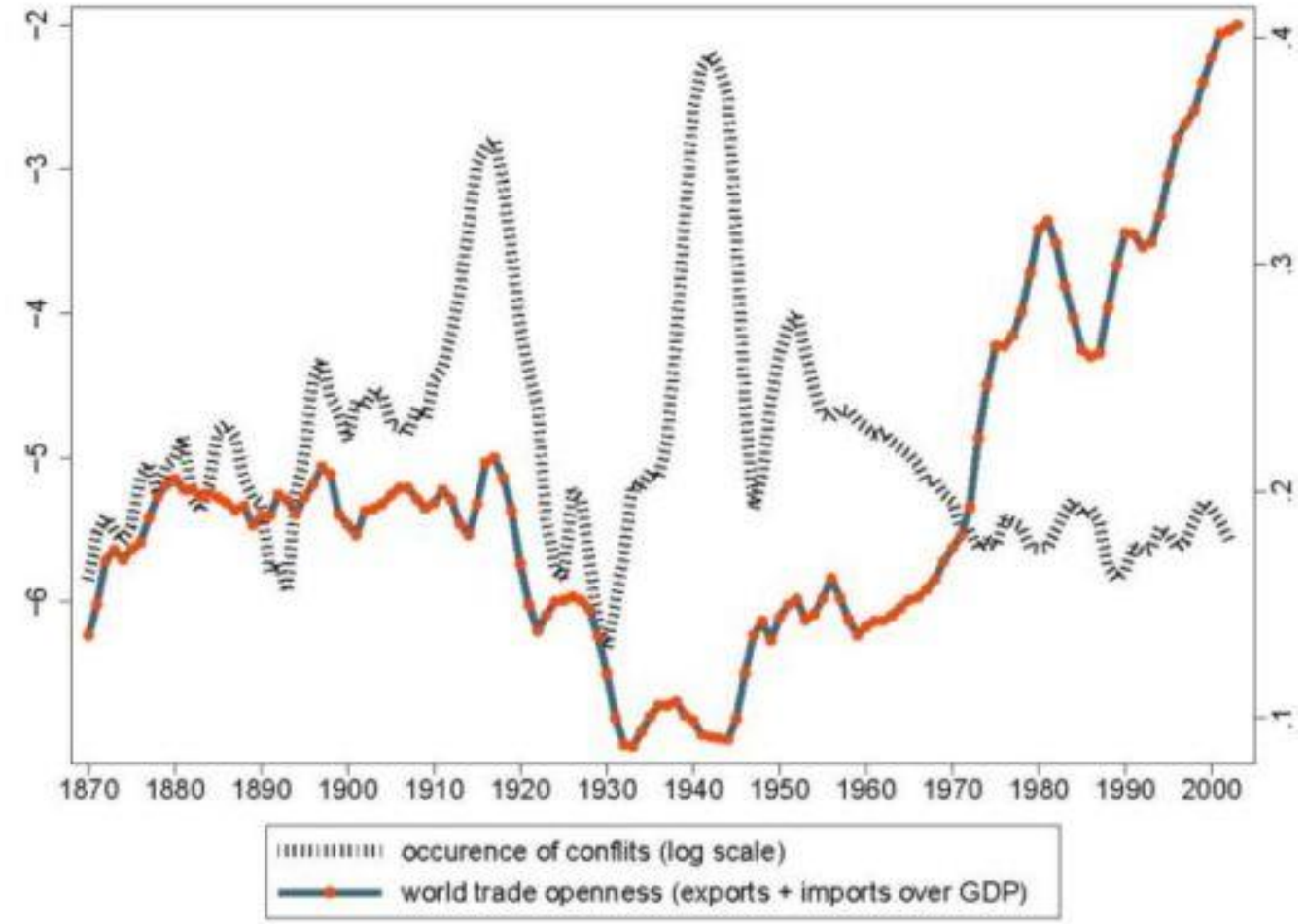
A network that shows the knowledge transfer, with different levels of complexity

IPR=Intellectual property registration



Source: Pinto, 2017

Large global factors



Source: VoxEU, CEPR's policy portal

Specific factors

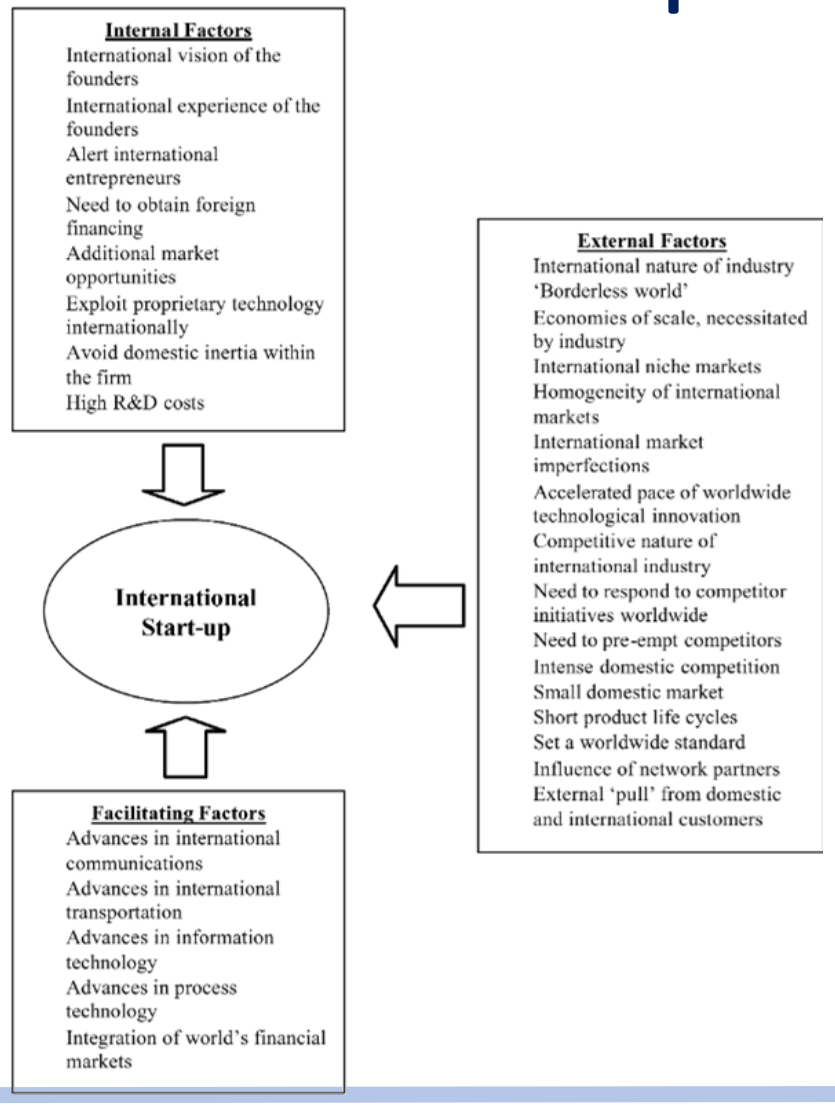
Ports worldwide

	1965	1970
Port labour productivity, tonnes per hour	1.7	30.0
Average ship size, tonnes	8.4	19.7
Number of loading ports in Europe	11	3
Insurance costs†, £ per tonne	0.24	0.04
Value of goods in transit‡, £ per tonne	2	1

*Deflated by US consumer prices
†Australia to Europe ‡Hamburg to Sydney

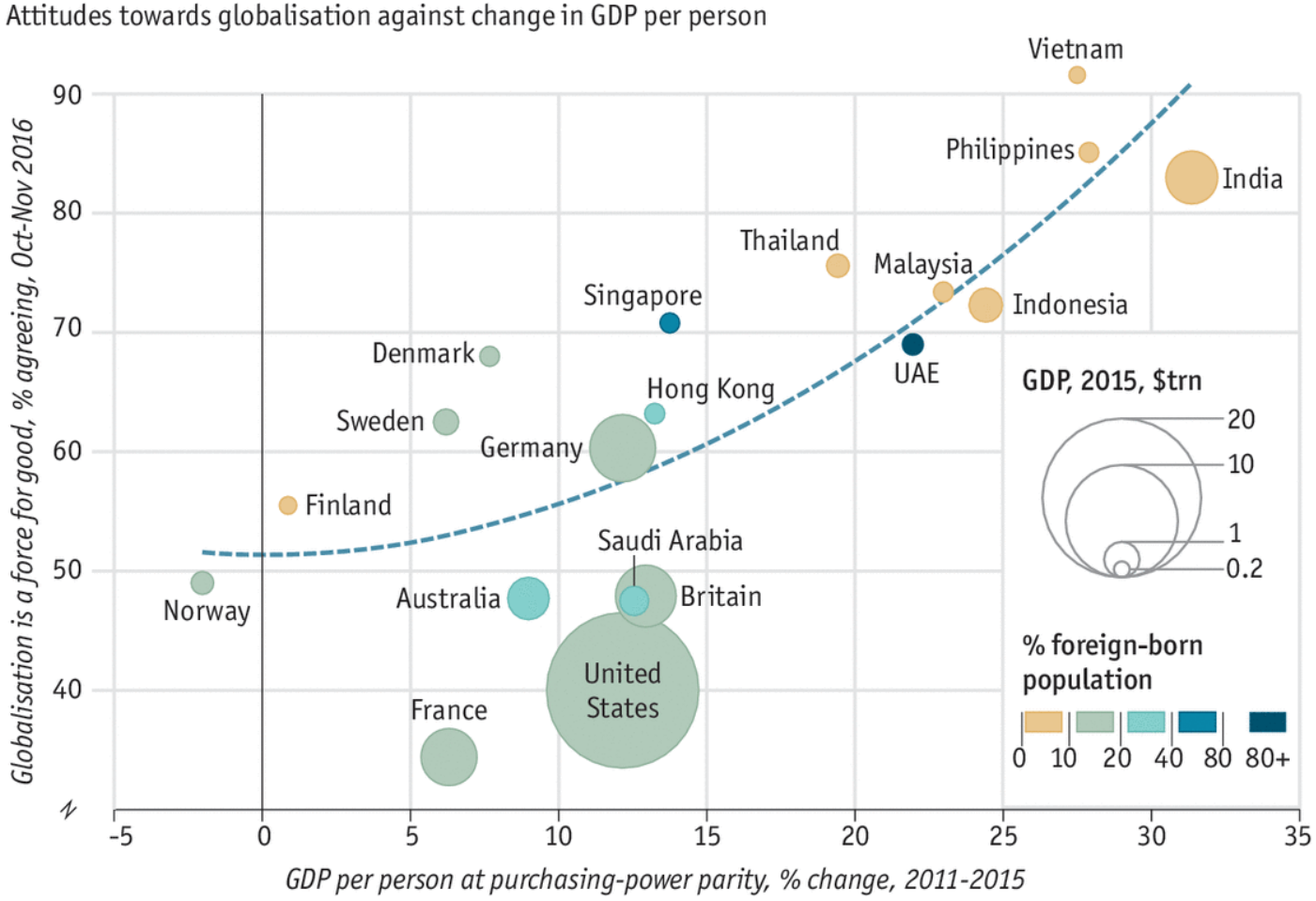
Source: The Economist, May 18, 2013

Globalisation even at the start-up stage



Source: Johnson, 2004

The perception of globalisation



Sources: YouGov/*The Economist;* World Bank; UN

Economist.com

Managing international network

- Culture has been shown to affect aspects of social and organizational life including **negotiation behaviour** (Graham, Mintu, & Rodgers, 1994), **acceptance of new products** (Yeniyurt & Townsend, 2003), **whistle blowing** (Sims & Keenan, 1999), **reward allocation** (Kim, Park, & Suzuki, 1990), **conflict management** (Swierczek & Onishi, 2003), **ethical perception** (Cohen, Pant, & Sharp, 1995; MacArthur, 1996), **entrepreneurial potential and innovativeness** (Mueller & Thomas, 2001) and **expectation of service quality** (Furrer & Sudharshan, 2001).

Source: Currarini et al, 2014

Hofstede’s model of culture

There are six dimensions, but the last two have been added later

1. Power Distance related to the different solutions to the basic problem of human inequality;

2. Uncertainty Avoidance , related to the level of stress in a society in the face of an unknown future;

3. Individualism versus Collectivism, related to the integration of individuals into primary groups;

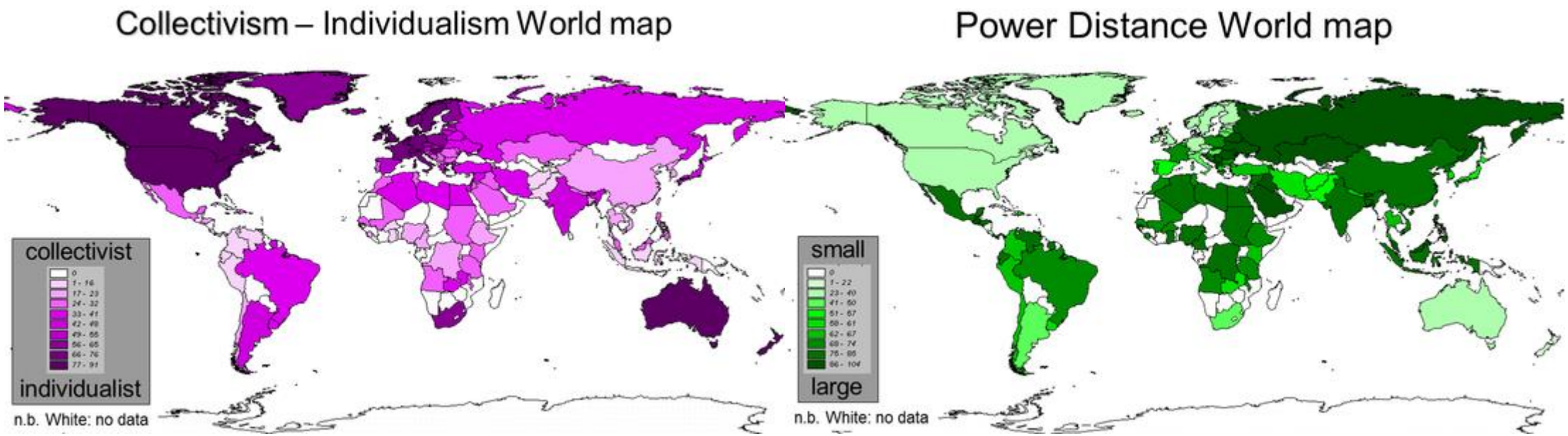
4. Masculinity versus Femininity, related to the division of emotional roles between women and men;

5. Long Term versus Short Term Orientation, related to the choice of focus for people's efforts: the future or the present and past.

6. Indulgence versus Restraint, related to the gratification versus control of basic human desires related to enjoying life

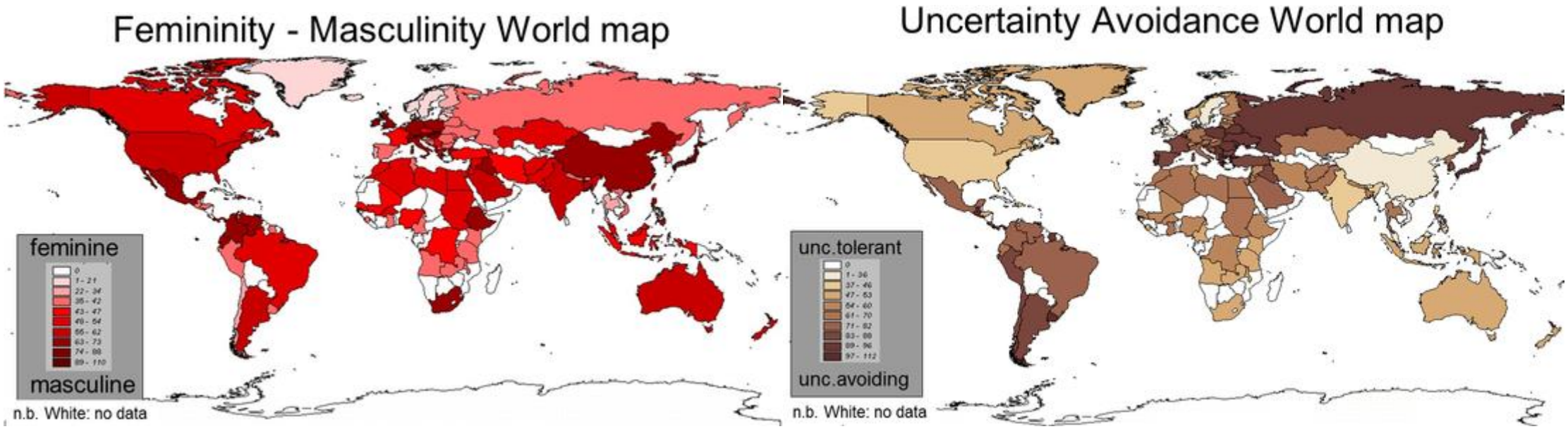
Source: Hofstede, 2011

Hofstede's model of culture



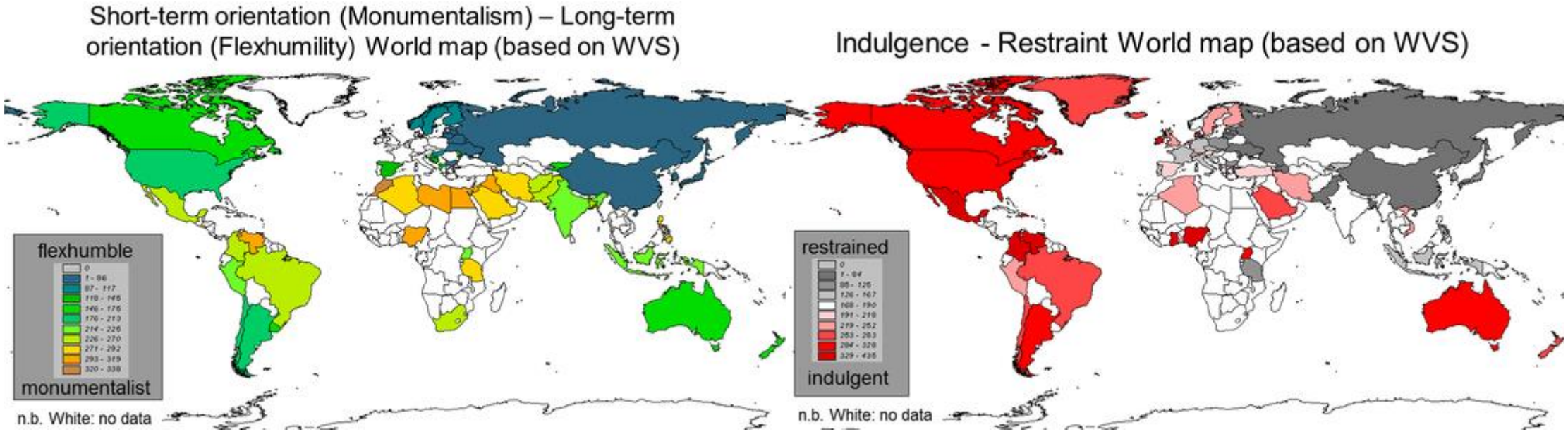
Source: geerthofstede.com, 2018

Hofstede's model of culture



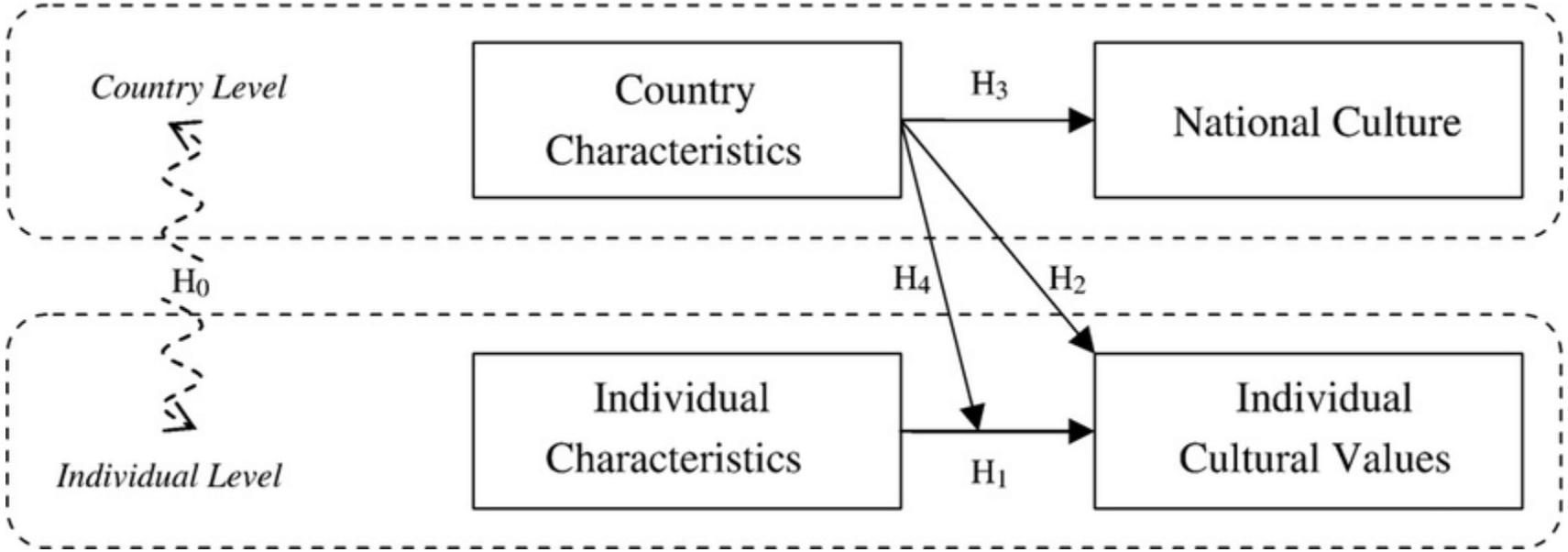
Source: geerthofstede.com, 2018

Hofstede's model of culture



Source: geerthofstede.com, 2018

Multi-level model of cultural values



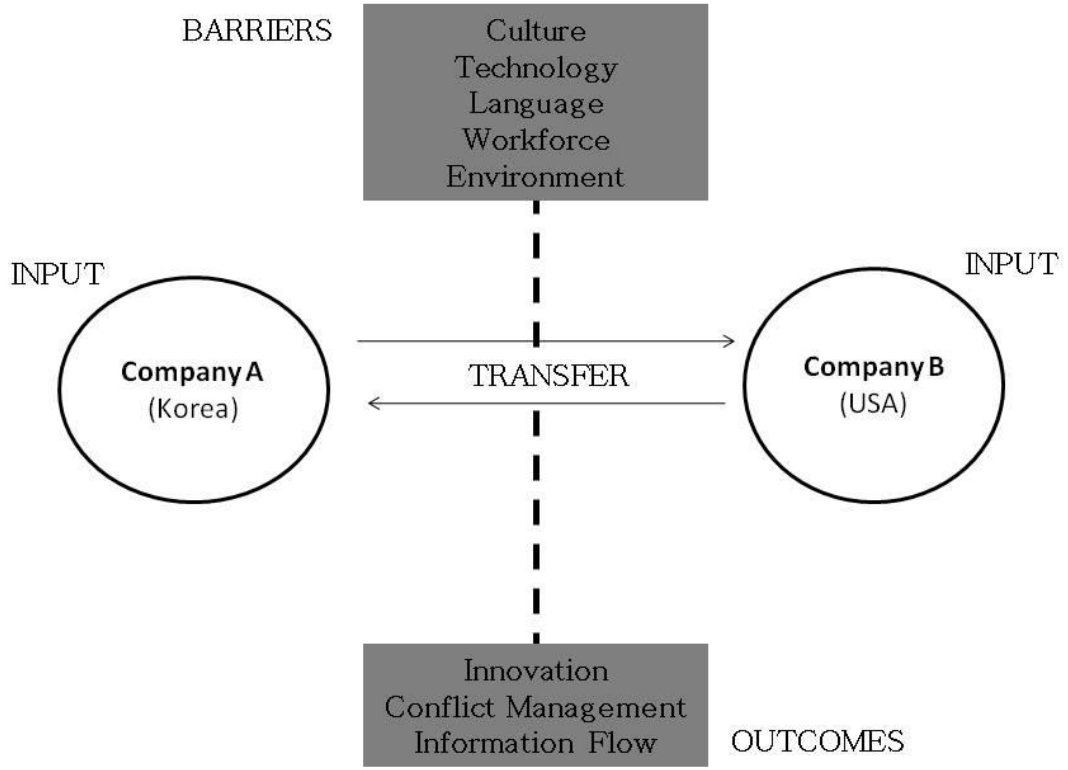
Source: Vas Taras, 2006

Hofstede's model of culture

- A review showed that the existing measures of culture are fairly consistent in terms of their approach and closely resemble the methodology used by Hofstede (1980). The vast majority of the existing instruments operationalize culture through values and the data are collected via self-report questionnaires.
- Culture is a multi-level, multi-facet construct. It has been generally agreed that culture is distinctively different from personality or individual temporal states as it is a group phenomena. "Culture is a group's shared set of distinct basic assumptions, values, practices, and artifacts that are formed and retained over a long period of time".
- Keep in mind that the data is limited and numbers are ordinal if not nominal in terms of interpretation.

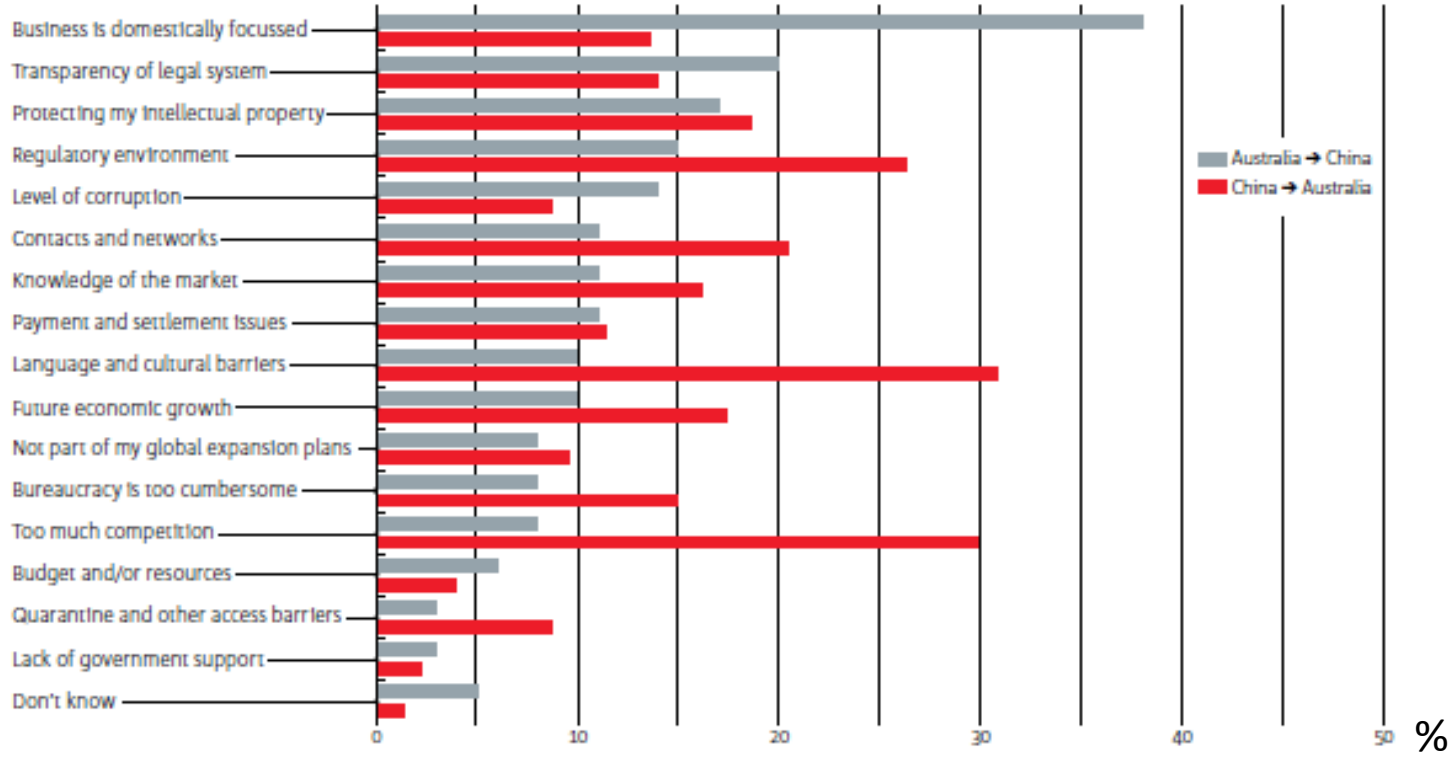
Source: Vas Taras et al, 2009

Barriers



Source: DOI: 10.5772/45816

Inhibitors for business engagement



Source: NAB ACRI Australia-China Business Index 2016

Questions?

jeroen.bergmann@eng.ox.ac.uk

Management Practice

13. Virtual management

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

24/11/2020

Course

Literature for the course:

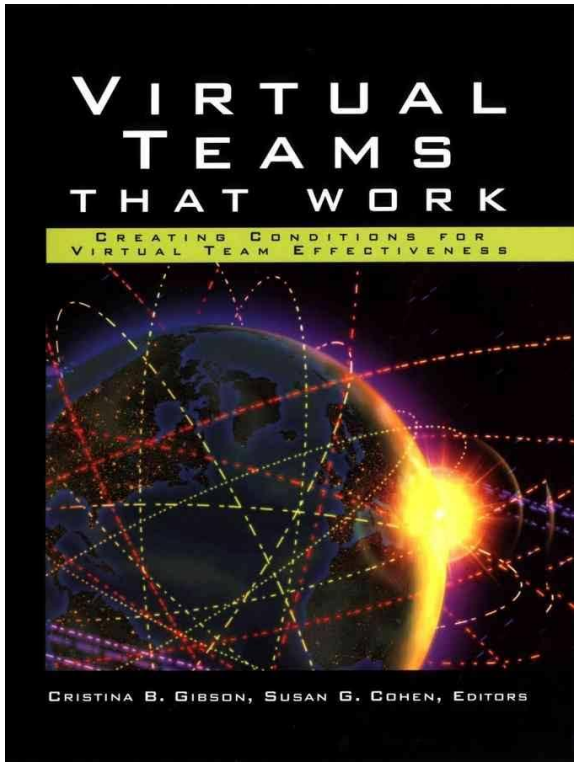
Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to provide a definition for a virtual team
- Understand the main challenges of virtual teams
- Able to describe factors that can help manage a global team
- Able to describe the components of a structural equation model

Literature for this session:

Gibson, Cristina B., and Susan G. Cohen, eds. Virtual teams that work: Creating conditions for virtual team effectiveness. John Wiley & Sons, 2003.



Remote working

4.3mil

People working remotely in the UK

Data from the ONS 2017.

57mins

The average daily commute in the UK

Data from the ONS 2018.

2+hrs

Is the daily commute for over 3.7 million people

Data from the ONS 2018.

73%

Workers put in more effort than is required when working from home

Research by Cardiff University 2017.

30%

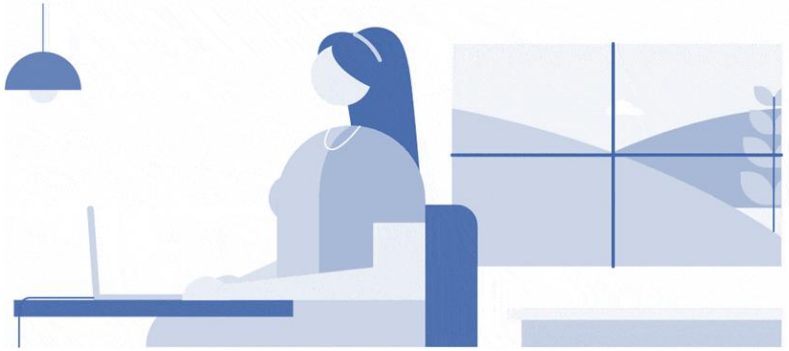
Workers feel their productivity increases when they work away from the office

Research by YouGov 2015.

70%

Workers feel it is important for businesses to allow their employees to work flexibly

Research by YouGov 2015.



26wks

After six months, an employee has the legal right to ask their employer for flexible working

The Flexible Working Regulations 2014.

Source: https://www.accountex.co.uk/insight/2018/10/22

The Economist Intelligence Unit

The rise of virtual teams

- The use of virtual offices is growing fast ...

US telecommuting
Total growth 2005-12, %

Total growth 79.7%

Non-profit organisations 87.6%

Federal government 421%

State government 122.1%

For-profit companies 70.4%

Local government 62.3%

- Most US employees now do at least some work out of the office—and prefer to do so **(% of workers)**

- Multinational companies rely on international teams

% of workers based abroad

General Electric 50%

Toyota 38%

Source: Global Workforce Analytics

But...

- Employees can become isolated
- Team building can suffer
- IT security and legal risks may emerge for employers

- Therefore team building for virtual teams is essential:

- Make sure that team members meet physically early on and then meet up regularly to build relationships. Individual tasks should be made clear so that a scattered team is not left chasing a general goal.
- Establish a regular, set schedule for communication between team members, set times for calls and, if necessary, guidelines for when to use phone, email and other devices. Ensure that a common language has been agreed upon for teams of different nationalities.
- Use reliable, proven technology. Team members must use shared, reliable IT platforms that are easy to access and secure.
- Monitor individual performance closely and ensure that team members take responsibility for individual tasks.
- Keep team sizes manageable: complex projects can lead to virtual teams of 100 or more people.

SIRM Foundation
Shaping the future of HR

Virtual teams

A virtual a team must have the following attributes:

- It is a functioning team—a collection of individuals who are **interdependent** in their tasks, **share responsibility** for outcomes, see themselves and are viewed by others as an **intact social unit** embedded in one or more social systems, and **collectively manage their relationships** across organizational boundaries.
- The members of the team are **geographically dispersed**.
- The team relies on **technology-mediated communications** rather than face-to-face interaction to accomplish their tasks.

Learning networks, communities of practice, Web-based interest groups, and other more loosely formed collectives are not defined as a virtual team.

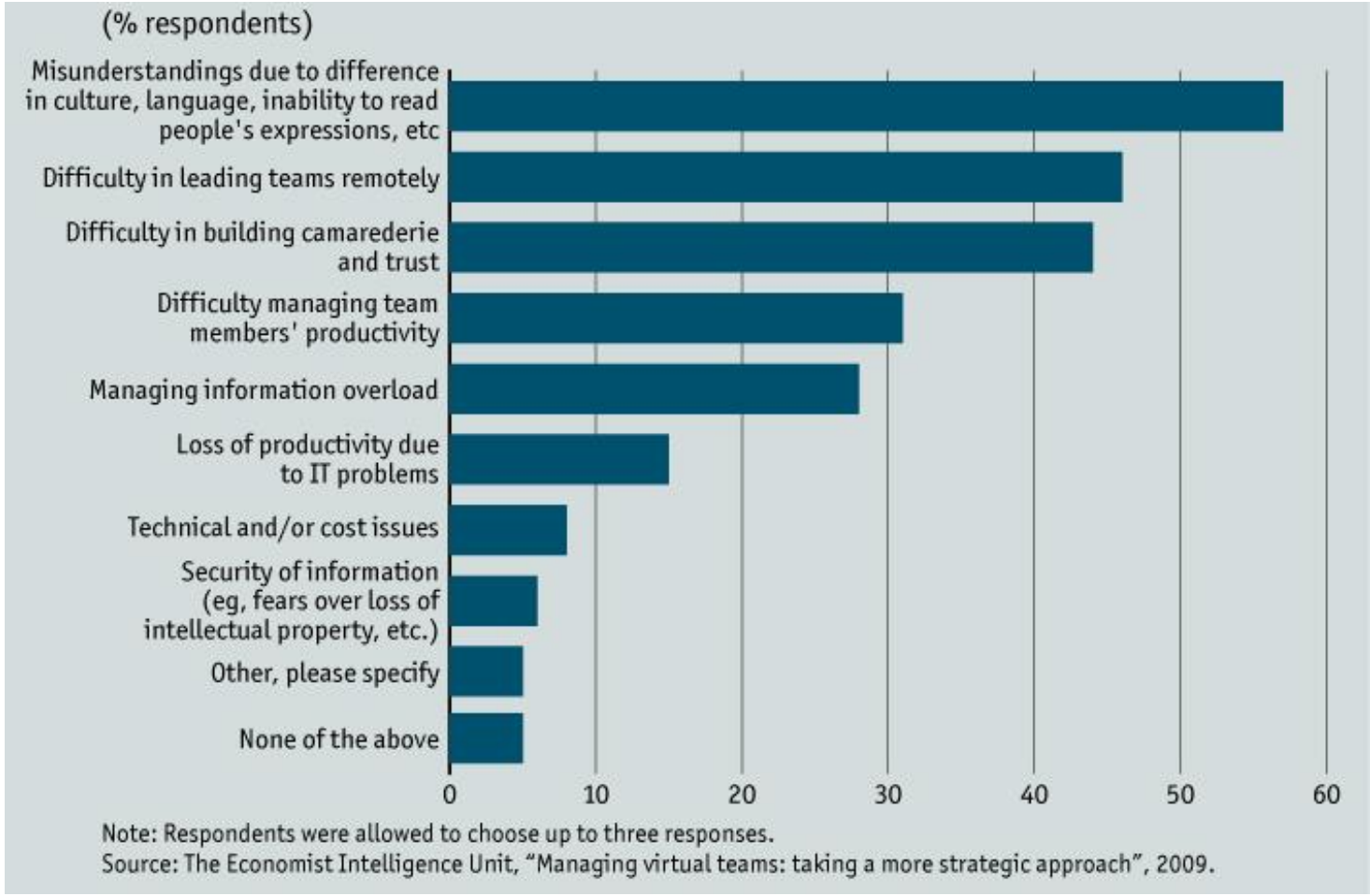
Source: Gibson et al, 2003; Hackman, 1987; Alderfer, 1977

Issue

- Higher probability for misunderstanding, as a lot of information that is important for successful communication (e.g. non-verbal and para-verbal communication) can be hidden.

Source: Lonner, Berry and Hofstede 1980

Challenges of managing a virtual team



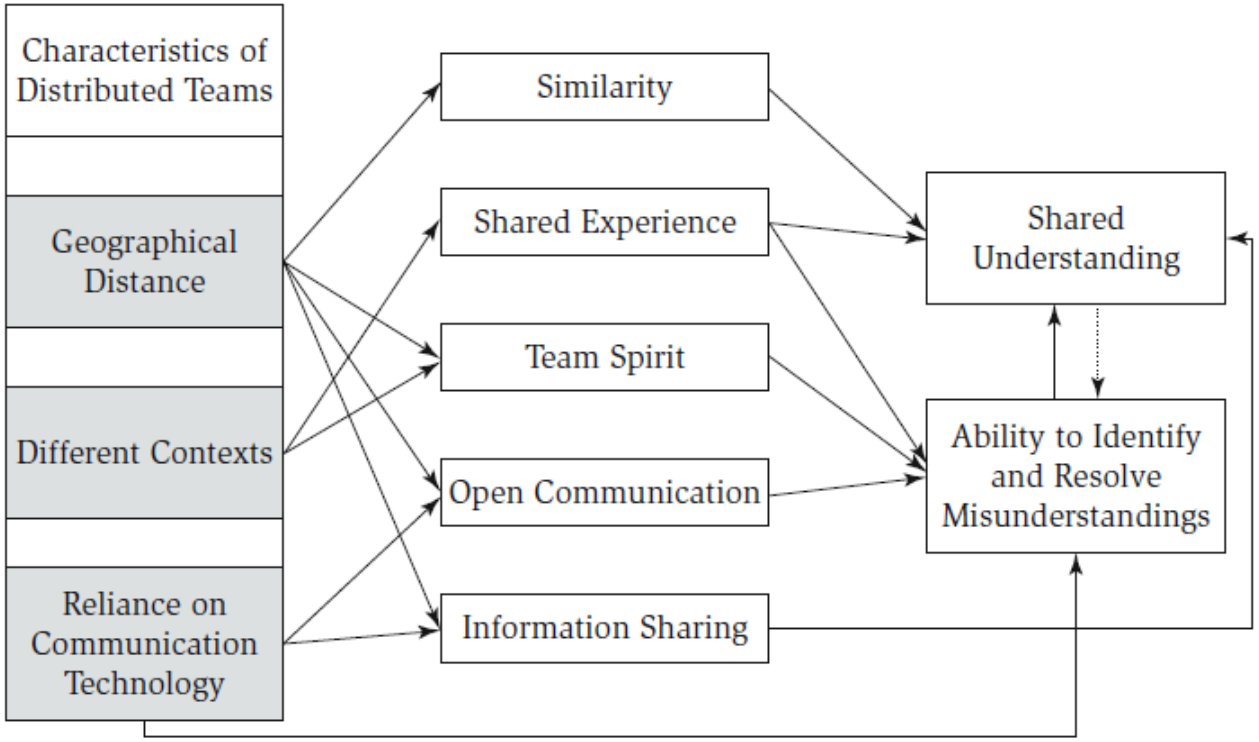
Shared understanding

- Shared understanding—a collective way of organizing relevant knowledge—can have a significant impact on the ability of teams to coordinate work and perform well.

- It provides the following benefits:
- Enables people to predict the behaviours of team members
- Facilitates efficient use of resources and effort
- Reduces implementation problems and errors
- Increases satisfaction and motivation of team members
- Reduces frustration and conflict among team members

Source: Gibson et al, 2003

Effects of Team Characteristics on Shared Understanding



Source: Gibson et al, 2003

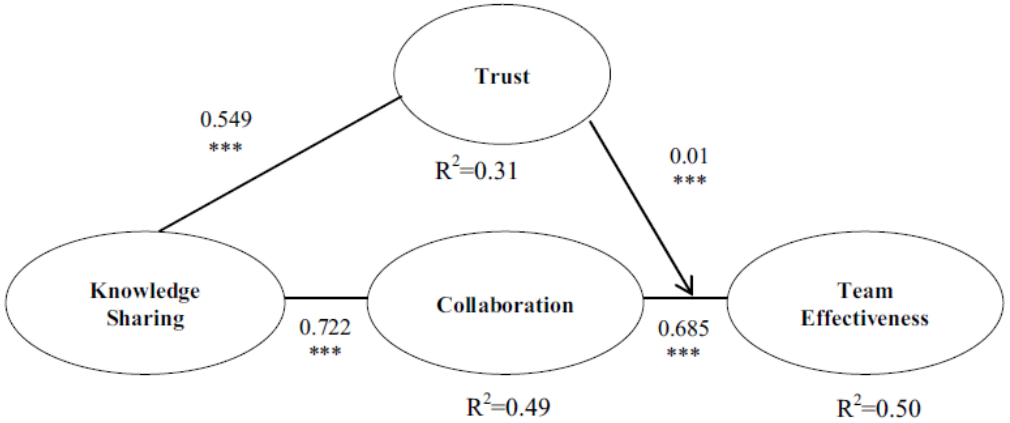
Facilitating shared understanding

- Compose teams in which members have similar backgrounds.
- Highlight and emphasize similarities among team members.
- Facilitate sharing of personal information, especially early in the project.
- Facilitate sharing of information about day-to-day activities throughout the project.
- Identify essential knowledge that is needed on the project, and make sure that this knowledge is shared, especially across sites.
- Encourage face-to-face meetings with team members early in the project and periodically throughout longer, more difficult projects.
- Encourage team members to visit the work locations of other team members.
- Build a strong team identity.
- Keep turnover low.
- Provide easy access to and support for (including training and technical support) videoconferencing and on-line team spaces.

Source: Gibson et al, 2003

Knowledge sharing

- A study showed the importance of knowledge sharing to virtual team effectiveness, and recommends that organizations support knowledge sharing in virtual settings on both technological and social levels. A PLS (partial least squares) analysis was performed.



Projection to latent structure

Source: Alsharo et al, 2017

Prediction method

- X: Independent variables
- Y: Dependent variables (predict Y from X)

$$Y = f(X)$$

Different options are available to predict Y based on X, but regression-based approaches are often applied.

However, regression-based approaches have several limitations:

- The postulation of a simple model structure
- The assumption that all variables can be considered as observable
- The conjecture that all variables are measured without error, which may limit their applicability in studying complex phenomena's in engineering management.

Source: Haenlein & Kaplan, 2004

Prediction

- Structural equation modeling (SEM) allows the simultaneous modeling of relationships among multiple independent and dependent constructs.
- SEM enables the constructing of unobservable variables measured by indicators (also called *items*) as well as to model measurement error for the observed variables.
- To estimate the parameters of an SEM, a covariance-based or variance-based approached can be used. Variance-based SEM is also known under the term partial least squares (PLS) analysis

Source: Haenlein & Kaplan, 2004; Gefen, Straub, & Boudreau, 2000

SEM

- SEM is often described as combining factor analytic and regression models into a single data analysis tool. Using the language of SEM, **latent variables (factors)** represent the concepts of the theory, and data from **measures (indicators)** are used as input for statistical analyses that provide evidence about the **relationships** of the latent variables with their indicators and relationships among the latent variables.

- It is a tool that is often used in management research.

Source: Williams et al 2009

SEM - definitions

- η (eta) = latent endogenous variable (value is determined by the states of other variables in the system)
- ξ (xi) = latent exogenous (i.e., independent) variable
- ζ (zeta) = random disturbance term
- γ (gamma) = path coefficient
- ϕ (phi) = non-causal relationship between two latent exogenous variables
- y_i = indicators of endogenous variables
- ε_i (epsilon) = measurement errors for indicators of endogenous variable
- λ_{yi} (lambda *y*) = loadings of indicators of endogenous variable
- x_i = indicators of exogenous variable
- δ_i (delta) = measurement errors for indicators of exogenous variable
- λ_{xi} (lambda *x*) = loadings of indicators of exogenous variable

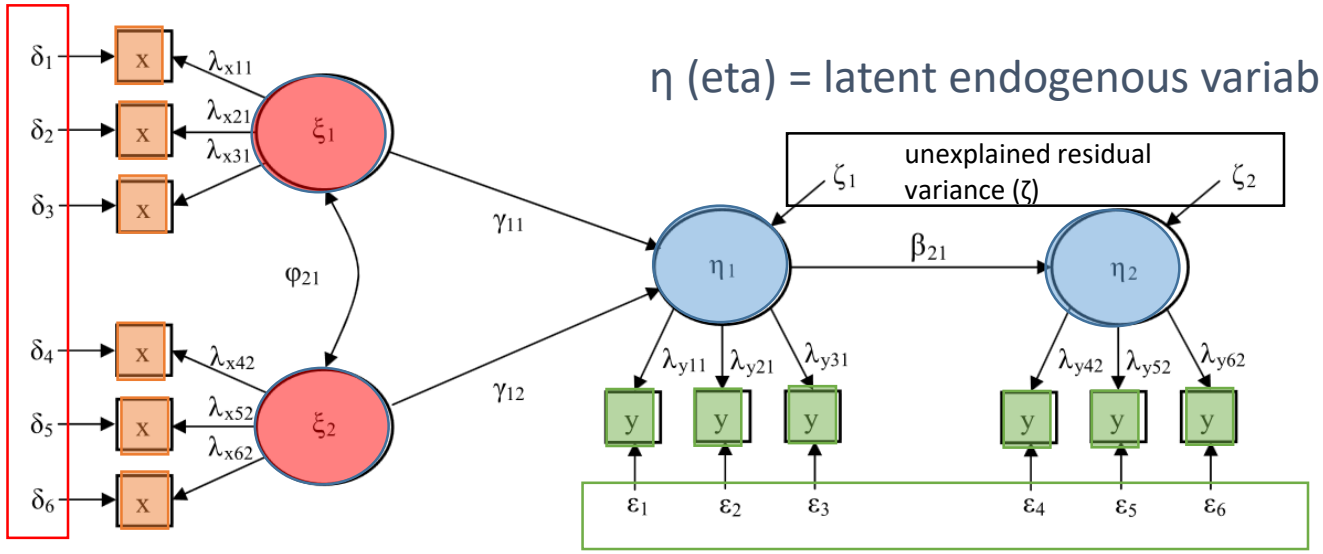
Price of material in a supply chain is **endogenous** because it is set by a producer in response to costumer demand.

Source: Haenlein & Kaplan, 2004

Example Model

- A circle is used to represent each of four latent variables
- The boxes represent associated indicator variables.
- The relationships between the latent variables and their indicators are often referred to as a measurement model, in that it represents or depicts an assumed process in which an underlying construct determines cause (e.g. response to a questionnaire)

x_i= indicators of exogenous variables



η (eta) = latent endogenous variable

ξ (xi) = latent exogenous (i.e., independent) variable

y_i= indicators of endogenous variables

λ_{yi} (lambda *y*) = loadings of indicators of endogenous variable

ε (epsilon) and δ (delta) are measurement errors

φ (phi) is a non-causal relationship between variables

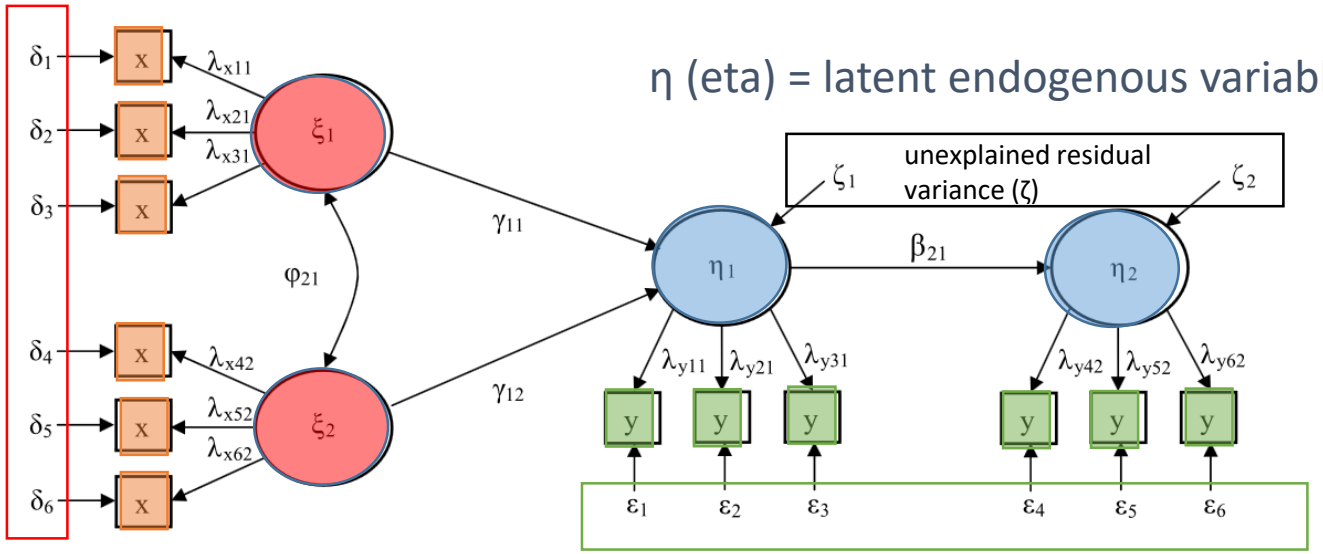
Source: Haenlein & Kaplan, 2004; Williams et al 2009

SEM

The first set relates the indicators of the exogenous variables (***x***) to their associated measurement error (**δ**) and the latent exogenous variables (**ξ**):

$$x_1 = \lambda_{x11}\,\xi_1 + \delta_1$$
$$x_2 = \lambda_{x21}\,\xi_1 + \delta_2$$
$$x_3 = \lambda_{x31}\,\xi_1 + \delta_3$$
$$x_4 = \lambda_{x42}\,\xi_2 + \delta_4$$
$$x_5 = \lambda_{x52}\,\xi_2 + \delta_5$$
$$x_6 = \lambda_{x62}\,\xi_2 + \delta_6$$

x_i= indicators of exogenous variables



η (eta) = latent endogenous variable

ξ (xi) = latent exogenous (i.e., independent) variable

y_i= indicators of endogenous variables

Source: Haenlein & Kaplan, 2004; Williams et al 2009

SEM

The second set describes the relationship between the indicators of the endogenous variables (**y**), their associated measurement error (**ε**), and the latent endogenous variables (**η**):

$y_1 = \lambda_{y11}\,\eta_1 + \varepsilon_1$

$y_2 = \lambda_{y21}\,\eta_1 + \varepsilon_2$

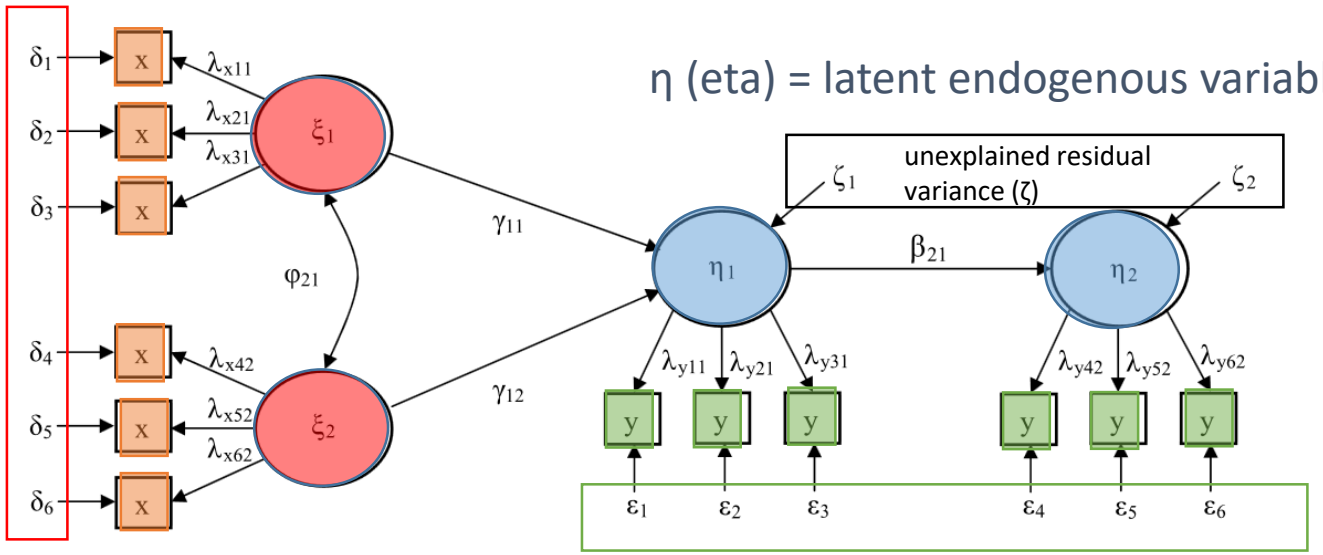
$y_3 = \lambda_{y31}\,\eta_1 + \varepsilon_3$

$y_4 = \lambda_{y42}\,\eta_2 + \varepsilon_4$

$y_5 = \lambda_{y52}\,\eta_2 + \varepsilon_5$

$y_6 = \lambda_{y62}\,\eta_2 + \varepsilon_6$

x_i= indicators of exogenous variables



η (eta) = latent endogenous variable

ξ (xi) = latent exogenous (i.e., independent) variable

y_i= indicators of endogenous variables

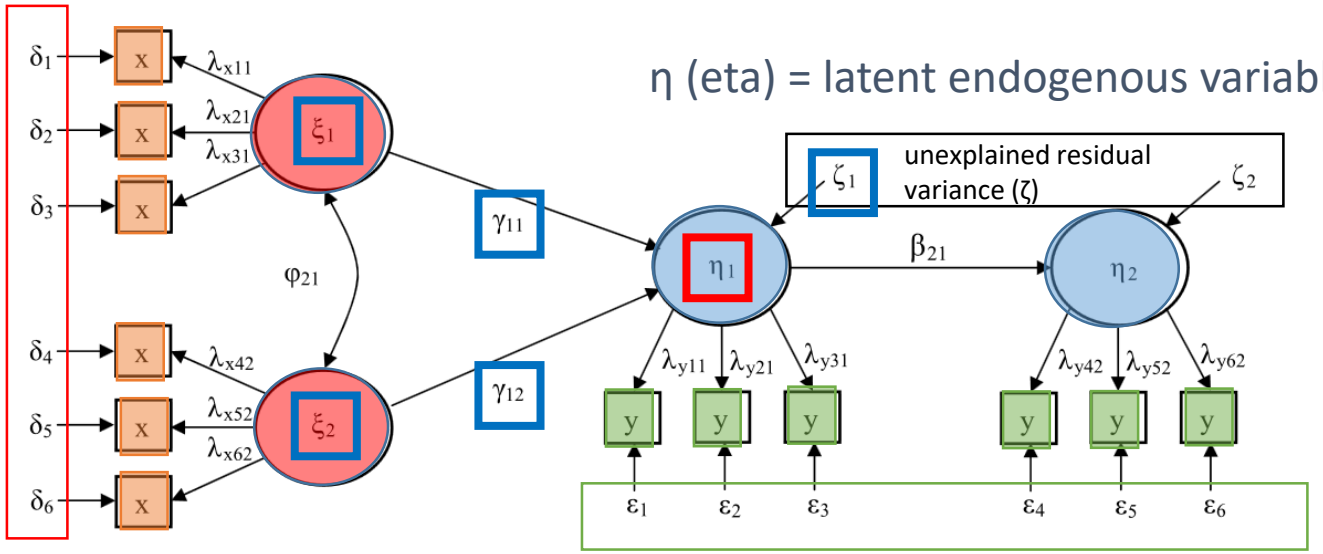
Source: Haenlein & Kaplan, 2004; Williams et al 2009

SEM

- The last set deals with the relationship between the latent endogenous (η) and exogenous (ξ) variables:

$\eta_1 = \gamma_{11}\,\xi_1 + \gamma_{12}\,\xi_2 + \zeta_1$

x_i= indicators of exogenous variables



η (eta) = latent endogenous variable

ξ (xi) = latent exogenous (i.e., independent) variable

y_i= indicators of endogenous variables

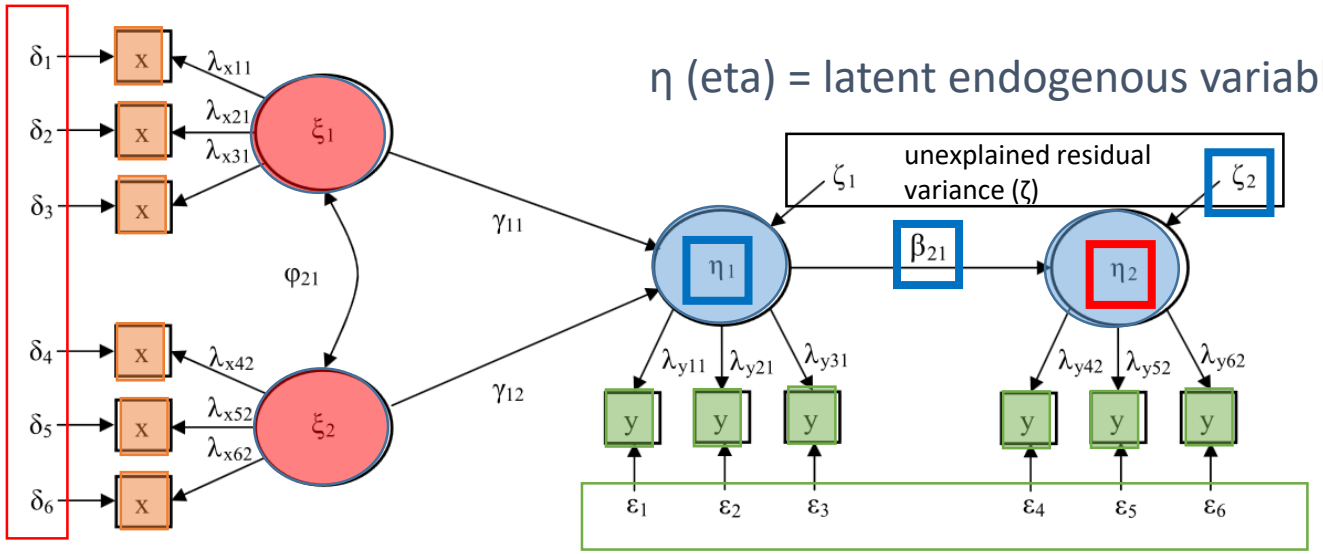
SEM

- The last set deals with the relationship between the latent endogenous (η) and exogenous (ξ) variables:

$\eta_1 = \gamma_{11}\,\xi_1 + \gamma_{12}\,\xi_2 + \zeta_1$

$\eta_2 = \beta_{21}\,\eta_1 + \zeta_2$

x_i= indicators of exogenous variables



ξ (xi) = latent exogenous (i.e., independent) variable

y_i= indicators of endogenous variables

Source: Haenlein & Kaplan, 2004; Williams et al 2009

SEM - disturbance terms

- The random disturbance terms ζ do not reflect measurement error, but are known as “errors in equations” and “reflect random disturbances (i.e. they indicate that the endogenous variables are not perfectly explained by the independent variables).

Source: Haenlein & Kaplan, 2004

SEM - Matrix

- Applying matrix algebra, the sets of equations can also be written in the following way

$x_1 = \lambda_{x11}\, \xi_1 + \delta_1 \ldots$

$y_1 = \lambda_{y11}\, \eta_1 + \varepsilon_1 \ldots$

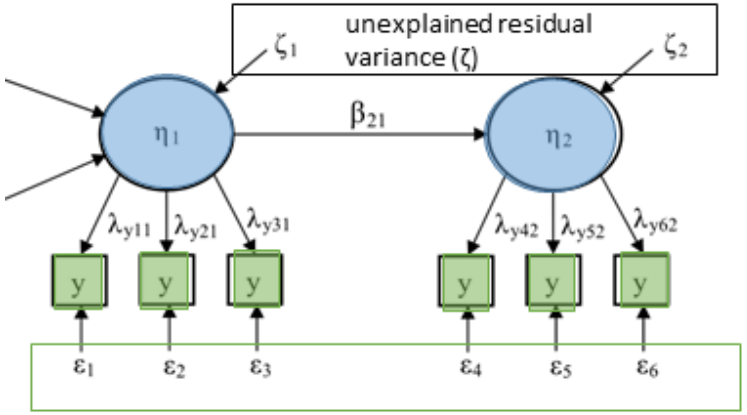
$\mathbf{x} = \boldsymbol{\lambda}_x \boldsymbol{\xi} + \boldsymbol{\delta}$

$\mathbf{y} = \boldsymbol{\lambda}_y \boldsymbol{\eta} + \boldsymbol{\varepsilon}$

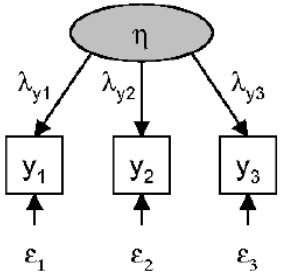
Source: Haenlein & Kaplan, 2004

Indicators

η (eta) = latent endogenous variable



Reflective indicators



- Depend on the latent variable
- Should be highly positively correlated
- Example: Timeliness
  - Accommodation of last minute requests
  - Punctuality in meeting deadlines
  - Speed of returning phone calls

Source: Haenlein & Kaplan, 2004

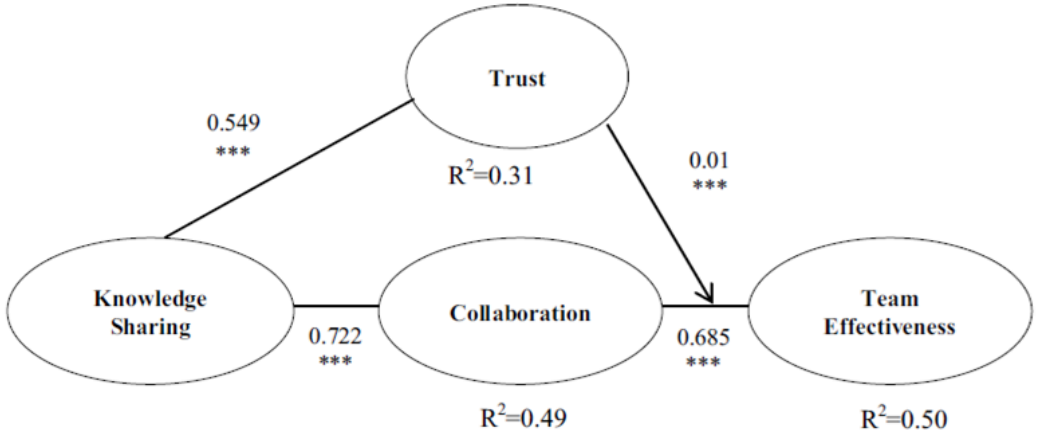
Partial Least Squares (PLS)

- The basic idea of PLS is quite straightforward:
- First, the weight relations (loadings), which link the indicators to their respective unobservable variables, are estimated.
- Second, case values for each unobservable variable are calculated, based on a weighted average of its indicators, using **the weight relations** as an input.
- Finally, these case values are used in a set of regression equations to determine the parameters for the structural relations

Source: Fornell & Bookstein, 1982

Knowledge sharing

- Knowledge Sharing has no R^2 value as it is an exogenous (independent) variable. The model explains 31% of the variance in Trust, 49% of collaboration variance and 50% of the variance in team effectiveness. The path coefficients between knowledge sharing and trust, knowledge sharing and collaboration, and collaboration and team effectiveness are significant at $p<0.002$.



Source: Alsharo et al, 2017

Trust

- Exploratory interview analysis performed by Gibson and Manuel suggests that teams with greater cultural differences (Team Europe Connect) were characterized by a greater proportion of negative expressions of trust than teams with fewer cultural differences (Aerospace Alliance and Auto Unification).

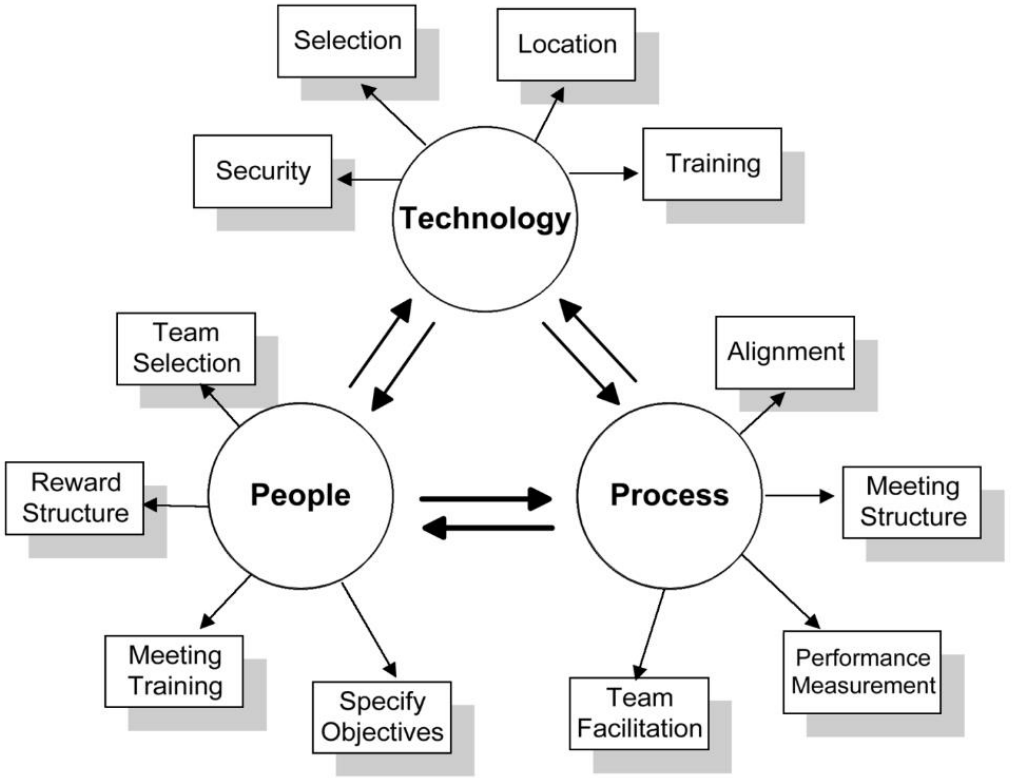
	Mean Number of Individual Negative Expressions of Trust	*Standard Deviation*
Europe Connect	10.88	5.38
Aerospace Alliance	2.88	2.52
Auto Unification	2.00	1.67
Total	4.39	4.69

(I) Team	*(J) Team*	*Mean Difference (I − J)*	*Standard Error*	*Significance*
Europe Connect	Aerospace Alliance	*7.9926	1.361	.011
	Auto Unification	*8.8750	1.475	.006
Aerospace Alliance	Europe Connect	*−7.9926	1.361	.011
	Auto Unification	.8824	1.229	.620
Auto Unification	Europe Connect	*−8.8750	1.475	.006
	Aerospace Alliance	−.8824	1.229	.620

Source: Gibson et al, 2003

Model of effective virtual team

A 12 elements model for effective virtual team working



Source: Bal & Gundry, 1999

Communication tool and style

- Virtual communication is often less frequent and less rich.
- Teams in which members have low language commonality could use a lean medium such as e-mail to increase the effectiveness of their communication.
- Teams with a high degree of cultural difference (see Hofstede) could select a rich medium when sharing complex messages.

Source: Klitmøller, Anders, and Jakob Lauring. 2013; DeSanctis, Wright and Jiang 2001.

Activity

The professional body for HR and people development provided a very practical overview:

https://www.cipd.co.uk/knowledge/fundamentals/relations/flexible-working/remote-working-top-tips

MPiE

Questions?

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Management Practice

14. Assignment in a global context

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MPiE

24/11/2020

Course

Literature for the course:

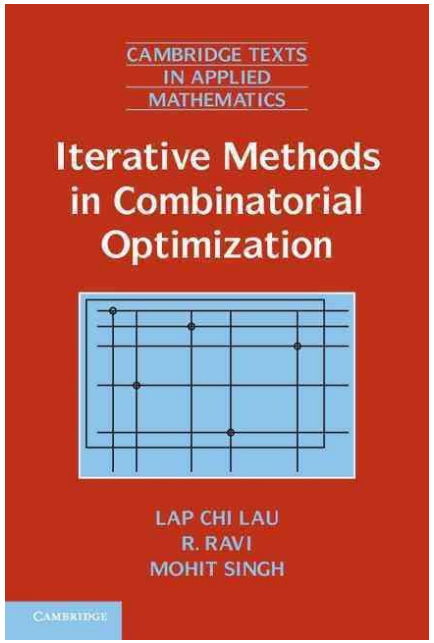
Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Understand what an assignment problem is
- Able to solve a Integer linear constrained optimization problem
- Able to apply the Hungarian Method
- Able to discuss difference between assignments methods

Literature for this session:

Lap Chi Lau, Ramamoorthi Ravi, and Mohit Singh. *Iterative methods in combinatorial optimization*. Vol. 46. Cambridge University Press, 2011.



Assignment

Assignment is the allocation of a job or task to someone.

The assignment supports the matching of personnel to specific tasks or more generically, assigning jobs to machines.

There is a benefit if we can optimise the assignments against a certain cost parameter.

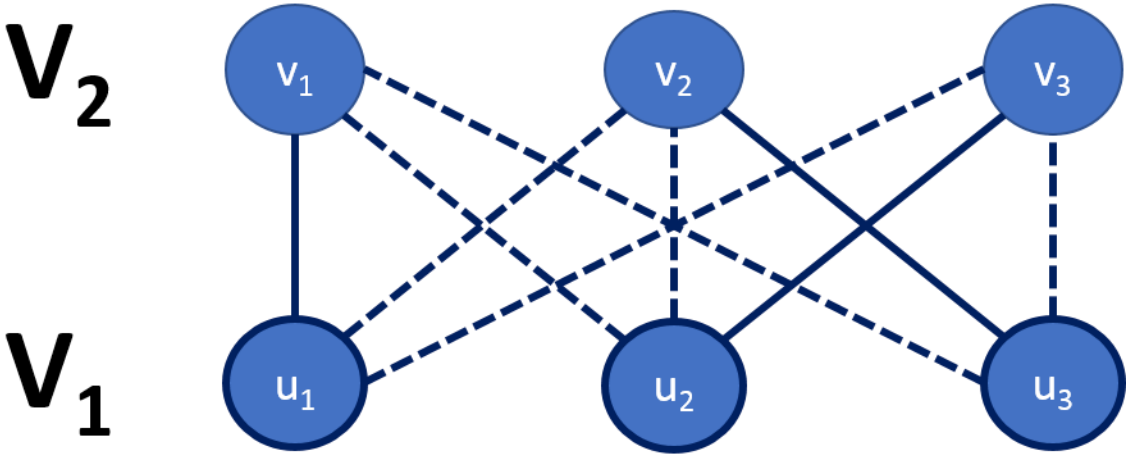
Assignment problem

- The assignment problem is one of the fundamental combinatorial optimization problems (finding in a finite set of objects the optimum) .
- Combinatorial optimization explores a finite (although countably infinite is also possible) set of potential solutions in search for an optimal solution.
- A set is countably infinite if its elements can be put in one-to-one correspondence with the set of natural numbers
- A criterion function that can be minimized or maximized can be used to define optimality.

Source: John and Lei, General assignment problem

Classic assignment problem

- Given a bipartite graph $G=(V_1 \cup V_2, E)$ and weight w, the objective is to match every vertex in V_1 with a distinct vertex in V_2 to minimize the total weight (cost) of the matching. This is also know as the minimum weight bipartite matching problem and is a fundamental problem in combinatorial optimisation.



Source: Lau et al, 2011

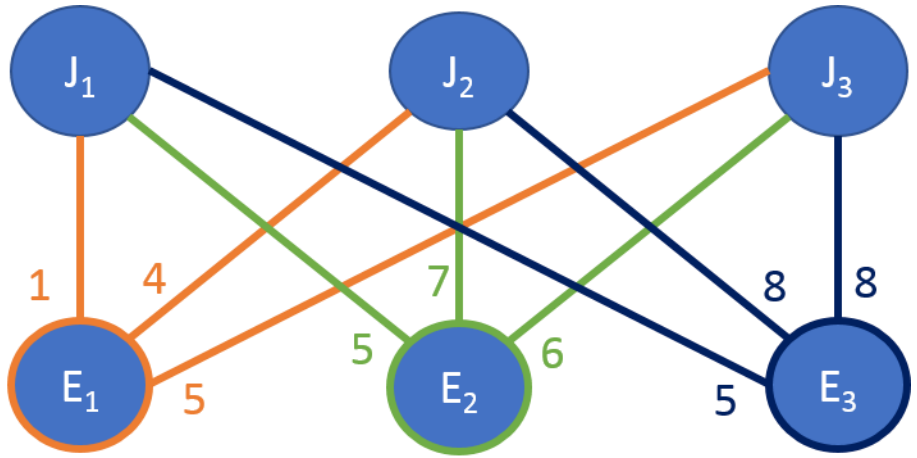
Example assignment problem

- 3 employees can be put on 3 jobs
- Each employee can only work on one job.
- The suitability of each employee for each of the jobs can be captured by a cost value. The cost will be **lower** if the employee is more suitable for that job.

Source: Shun Y. Cheung, 2012

Example assignment problem

- Find a maximum matching (assign jobs to as many employees as possible) for which the sum of the cost of the edges is minimized



Source: Shun Y. Cheung, 2012

Potential solution for assignment problem

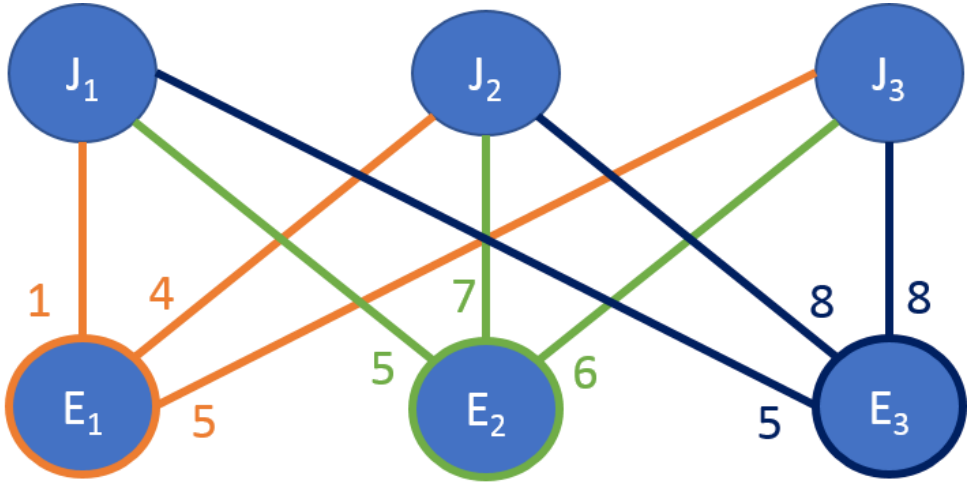
- Find all maximum matchings

{$E_1 \rightarrow J_1$, $E_2 \rightarrow J_2$, $E_3 \rightarrow J_3$}; {$E_1 \rightarrow J_2$, $E_2 \rightarrow J_1$, $E_3 \rightarrow J_3$}, …

- Sum the cost of the edges of each maximum matching

{16}; {17}, …

- Select the maximum matching with the lowest possible cost



Source: Shun Y. Cheung, 2012

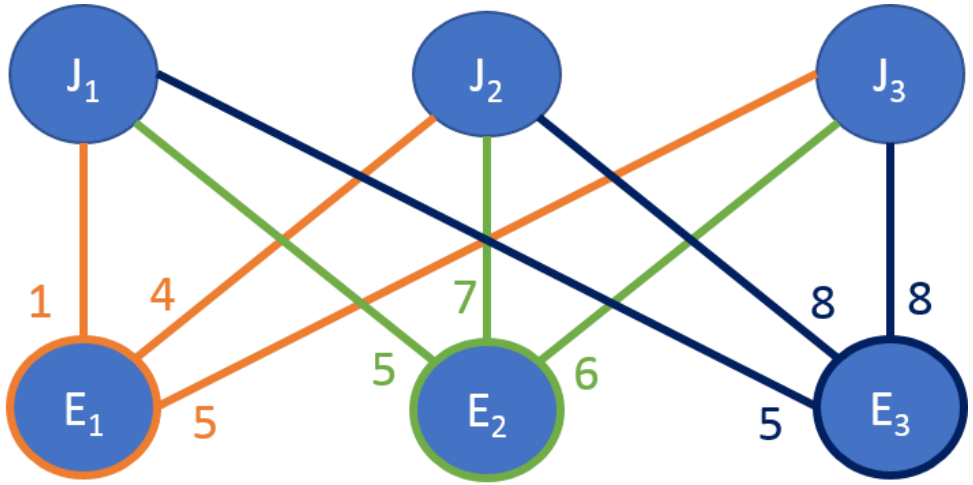
Optimal assignment

- An assignment is a set of *n* entry positions in the cost matrix, no two of which lie in the same row or column.
- The sum of the *n* entries of an assignment is its cost.
- An assignment with the smallest possible cost is called an optimal assignment.

Source: Shun Y. Cheung, 2012

Integer linear constrained optimization problem (IP)

- Set up cost matrix



C	J_1	J_2	J_3
E_1	1	4	5
E_2	5	7	6
E_3	5	8	8

Source: Shun Y. Cheung, 2012

Integer linear constrained optimization problem (IP)

C	J_1	J_2	J_3
E_1	1	4	5
E_2	5	7	6
E_3	5	8	8

- Cost matrix $C = [c_{ij}]$ where c_{ij} is the cost of Employee *i* working on Job *j*
- A variable x_{ij} is generated that has a binary set: [0] OR [1]
- The value [1] indicates that for x_{ij} the Employee *i* is assigned Job *j*.
- The value [0] is used otherwise (no assignment took place)

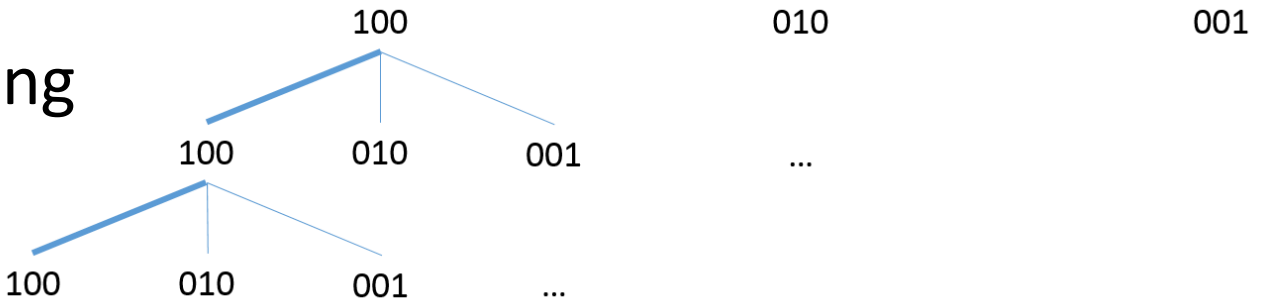
Source: Shun Y. Cheung, 2012

IP

- Minimize: $1x_{11}+4x_{12}+5x_{13}+5x_{21}+7x_{22}+6x_{23}+5x_{31}+8x_{32}+8x_{33}$

C	J_1	J_2	J_3
E_1	1	4	5
E_2	5	7	6
E_3	5	8	8

- Solution tree (3^3)
- Select only maximum matching



Source: Shun Y. Cheung, 2012

IP

- Algorithm output provides two possible options

C=15	J_1	J_2	J_3
E_1	0	4	0
E_2	0	0	6
E_3	5	0	0
C=15	**J_1**	**J_2**	**J_3**
E_1	1	0	0
E_2	0	0	6
E_3	0	8	0

- This was selected from 6 possible outcomes {16, **15**, 17, **15**, 18, 17}

Source: Shun Y. Cheung, 2012

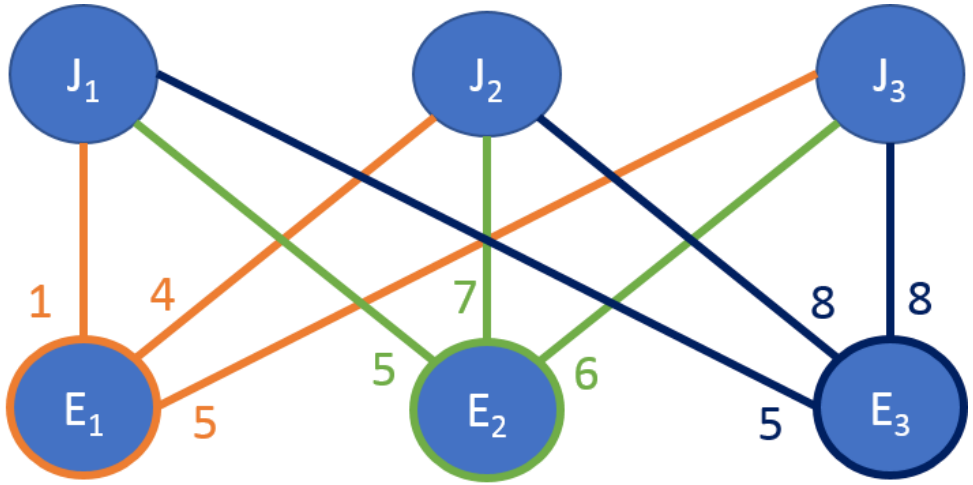
Simplex Algorithm for network problems

- A general purpose algorithm to find the optimum of a linear cost function with linear constraints is the Simplex Algorithm.
- A specially adapted Simplex algorithm is the Hungarian Algorithm.
- Although it was developed by Harold Kuhn, much of the work relied on the Hungarians Jenő Egerváry and Dénes Kőnig.
- If a number is added to or subtracted from all of the entries of any one row or column of a cost matrix, then on optimal assignment for the resulting cost matrix is also an optimal assignment for the original cost matrix.

Source: Shun Y. Cheung, 2012; Derek Bruff 2005

Hungarian Method

- Original cost matrix



C	J_1	J_2	J_3
E_1	1	4	5
E_2	5	7	6
E_3	5	8	8

Source: Shun Y. Cheung, 2012

Hungarian Method

(1) Subtract the smallest entry in each row from all the entries of its row.

C	J_1	J_2	J_3
E_1	**1**	4	5
E_2	**5**	7	6
E_3	**5**	8	8

C	J_1	J_2	J_3
E_1	0	3	4
E_2	0	2	1
E_3	0	3	3

Source: Shun Y. Cheung, 2012

Hungarian Method

(2) Subtract the smallest entry in each column from all the entries of its column.

C	J_1	J_2	J_3
E_1	0	3	4
E_2	0	**2**	**1**
E_3	0	3	3

C	J_1	J_2	J_3
E_1	0	1	3
E_2	0	0	0
E_3	0	1	2

Source: Shun Y. Cheung, 2012

Hungarian Method

- (3) Draw lines through appropriate rows and columns so that all the zero entries of the cost matrix are covered and the minimum number of such lines is used.

C	J_1	J_2	J_3
E_1	0	1	3
E_2	0	0	0
E_3	0	1	2

Source: Shun Y. Cheung, 2012

Hungarian Method

- (4) Test for Optimality:

(i) If the minimum number of covering lines is *n* (number of rows or columns), an optimal assignment of zeros is possible and we are finished.

(ii) If the minimum number of covering lines is less than *n*, an optimal assignment of zeros is not yet possible. In that case, proceed to Step 5.

n>2

C	J_1	J_2	J_3
E_1	0	1	3
E_2	0	0	0
E_3	0	1	2

Source: Shun Y. Cheung, 2012

Hungarian Method

- (5) Determine the smallest entry not covered by any line. **Subtract this entry from each uncovered row**, and then add it to each covered column. Return to Step 3.

C	J_1	J_2	J_3
E_1	0	1	3
E_2	0	0	0
E_3	0	1	2

C	J_1	J_2	J_3
E_1	-1	0	2
E_2	0	0	0
E_3	-1	0	1

Source: Shun Y. Cheung, 2012

Hungarian Method

- (5) Take the smallest entry that was not covered by any line. Subtract this entry from each uncovered row, and **then add it to each covered column**. Return to Step 3.

C	J_1	J_2	J_3
E_1	-1	0	2
E_2	0	0	0
E_3	-1	0	1

C	J_1	J_2	J_3
E_1	0	0	2
E_2	1	0	0
E_3	0	0	1

Source: Shun Y. Cheung, 2012

Hungarian Method

- (3) Draw lines through appropriate rows and columns so that all the zero entries of the cost matrix are covered and the minimum number of such lines is used.

n=3

C	J_1	J_2	J_3
E_1	0	0	2
E_2	1	0	0
E_3	0	0	1

4 (i) If the minimum number of covering lines is *n*, an optimal assignment of zeros is possible and we are finished.

Source: Shun Y. Cheung, 2012

Hungarian Method

- Algorithm output provides two possible options

C=15	J_1	J_2	J_3
E_1	0	**0**	2
E_2	1	0	**0**
E_3	**0**	0	1
C=15	J_1	J_2	J_3
E_1	**0**	0	2
E_2	1	0	**0**
E_3	0	**0**	1

Source: Shun Y. Cheung, 2012

IP

- Algorithm output provides the same two possible options

C=15	J_1	J_2	J_3
E_1	0	**4**	0
E_2	0	0	**6**
E_3	**5**	0	0
C=15	J_1	J_2	J_3
E_1	**1**	0	0
E_2	0	0	**6**
E_3	0	**8**	0

- They yield similar results

Source: Shun Y. Cheung, 2012

Hungarian algorithm

- The original algorithm has a computational complexity of $O(n^4)$.
- The algorithm can be improved by scanning rows and columns in parallell.
- The computational times have been reduced by a range of improvements, but the basic idea still provides the framework for many publsihed variations of the Hungarian algorithm.

Source: Jonker and Volgenant, 1986

Example: global assignment of personnel

- As more companies expand globally, they are also increasing international assignments and relying on expatriates to manage their global operations.
- Around 83 % of employers offer short-term assignments (T< 1 year), 97 % offer long-term assignments (1<T<5 years) and 61% offer permanent transfer.
- The international assignment requires additional specifications that reflect barriers in globalisation
- Determining who is suitable for an international assignment is an important decision point within international people management

Source: Society of HR management, 2017; KPMG's Global Assignment Policies and Practices Survey

International assignment

- Traditionally, organizations have relied on technical, job-related skills as the main criteria for selecting candidates for overseas assignments, but assessing global mindset is equally, if not more, important for successful assignments.

- Research points to three major attributes of successful expatriates:
  - **Intellectual capital.** Knowledge, skills, understanding and cognitive complexity.
  - **Psychological capital.** The ability to function successfully in the host country through internal acceptance of different cultures and a strong desire to learn from new experiences.
  - **Social capital.** The ability to build trusting relationships with local stakeholders, whether they are employees, supply chain partners or customers.

- This can be captured under a suitability value for each employee. This makes the international assignment problem a combinatorial optimization problem.

Source: Society of HR management, 2017; 2018

International assignment additional pointers

- An effective global communication plan will help expatriates feel connected to the home office and will alert them to changes that occur while they are away.
- The Internet, e-mail and intranets are inexpensive and easy ways to bring expatriates into the loop. In addition to formal e-mail communications, organizations should encourage home-office employees to keep in touch with peers on overseas assignments. Employee newsletters that feature global news and expatriate assignments are also encouraged.

Source: Society of HR management, 2017; 2018

Questions?

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Management Practice

15. Personal development planning

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

30/11/2020

Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to describe the value of personal development planning (PDP) within management
- Able to describe the reflective process
- Able to relate PDP to lifelong learning within a company
- Able to complete a PDP

Industry productivity measurements

$$\frac{Q_t}{Q_{t-1}} = \exp\left[\sum_{i=1}^{n} w_{i,t}\left(\ln\frac{q_{i,t}}{q_{i,t-1}}\right)\right]$$

where

Q = the aggregate quantity of industry output, expressed as an annual index,

n = number of products,

q = quantity of product i in year t; upon which is computed the natural logarithm of the ratio of quantity in the current year to that of the previous year, and

w = the average value share weight for product i in time t.

The average value share weight for product i is computed as:

$$w_{i,t} = \left(s_{i,t} + s_{i,t-1}\right) \div 2$$

where
s = the yearly share weight for product i in year t, which in turn is computed as:

$$s_{i,t} = p_{i,t}q_{i,t} \div \left(\sum_{i=1}^{n} p_{i,t}q_{i,t}\right)$$

where
p = price of product i at time t.

$$\frac{Q_t}{Q_0} \div \frac{L_t}{L_0}$$

where

Q = quantity of aggregate output, expressed as an annual index,

L = total labor hours worked, expressed as an annual index,

t = the current year, and
0 = the base year.

Source: www.bls.gov/opub/hom/inp/calculation.htm

Industry productivity and human capital

- Industry productivity are affected by human capital

- It is likely that initially there are some adjusted costs associated with the introduction of new skills and capital into the workplace which are then followed by positive improvements in productivity

Source: Black, Sandra E., and Lisa M. Lynch. "Human-capital investments and productivity." The American economic review 86.2 (1996): 263-267.

Human capital

- Human capital can be defined as skills and knowledge that individuals acquire through investments in schooling, on-the-job training, and other types of experience as suggested by Becker (1964)
- Human capital theory was originally developed to estimate employees' income distribution from their investments in human capital

Source: Unger et a, 2011

Human capital in entrepreneurship

The entrepreneurship literature provides a number of arguments on how human capital should increase entrepreneurial success.

1. Human capital increases the capability of owners to perform the generic entrepreneurial tasks of discovering and exploiting business opportunities.
2. Human capital is positively related to planning and venture strategy, which in turn, positively impacts success.
3. Knowledge is helpful for acquiring other utilitarian resources such as financial and physical capital.
4. Human capital is a prerequisite for further learning and assists in the accumulation of new knowledge and skills

Source: Unger et a, 2011

Development of your employees

- Apple reinforces that employees have to be self-reliant and develop skills on their own.
- “We’re supporting leaders in spotting potential at every level, driving personal development through best-in-class learning and skills training” Dyson
- At Facebook, most of the learning is employee-driven
- It is very important to invest in the employees by enabling and encouraging them to continuously reflect, learn and develop.

Source: Beausaert et al 2011

Self reflection

- Developing a new breed of senior managers that have the knowledge, the sensitivity, and the abilities necessary to lead organizations throughout the uncertain times ahead.

- The aim of self reflection is to take greater control of your knowledge acquisition and skill development, to increase your behavioural repertoire and leadership flexibility.

- Reflecting provides insight into the employee's own processes of learning.

Source: Ghoshal, Arnzen, & Brownfield, 1992; McMullan et al., 2003

Reflective process

Source: Nesbit, 2012

Personal development planning

- Personal Development Planning (PDP) is a process designed to enable you to think about, and plan for, your own career development.

- In general a PDP can be described as an assessment tool embedded in a larger assessment cycle of development and performance interviews. It is used to gather and document information about the competencies the employee worked on and is planning to further develop in the near future.

Source: Nesbit, 2012; Beausaert et al 2012

The PDP

- It gives an overview of the competencies the employee worked on in the past (looking back) and of the competencies the employee is planning to work on in the future (looking forward).
- It is composed by the employee himself (self-direction by the employee), although the format of the PDP is mostly fixed.
- It is used as basis for or to structure the conversations with the supervisor or the coach, who provides the employee with feedback and stimulates the employee's reflection.
- It serves different decision-making processes, ranging from planning an individual training-program to whether or not giving an employee a promotion.

Source: Brown, 1995; McMullan et al., 2003; Redman, 1994; Seng and Seng, 1996; Smith and Tillema, 1998; Snadden et al., 1996

PDP and professional development

- There is an increase in use of PDP in order to stimulate professional development, which is certainly related to the central role PDPs are taking in performance appraisal interviews nowadays.

- This is a direct driver for management to ensure that PDPs are correctly implemented.

- Keep in mind when a PDP is used for certification/assessment, presenting oneself in a positive light becomes more important

Source: Beausaert et al 2012; Beck et al., 2005

Value of PDP

- A review study indicated that most empirical studies show that PDP assessment is effective for learning, personal or professional development and improving professional practice.

- Bunker and Leggett (2004) did not find this positive relationship, so it is multidimensional.

- One limitation is that conclusions often rely on studies with small sample sizes. This indicates that care needs to be taken in terms of generalizability.

Source: Beausaert et al 2012; Bunker and Leggett, 2004; Bullock et al., 2007

One practical view (n=1)

- When creating development plans, managers and individuals should focus their goals around three areas: competence, passion, and organizational need.

- Your competence is areas of skill and ability in which you naturally do well.

- Your passion is things that energize you—those things you love to do, independent of how well you do them.

- The organizational needs are activities or service that are greatly needed and valued by your organization.

Source: Joseph Folkman ,Forbes, 2016

Continuing professional development (CDP)

- The PDP is an intermediate stage to CDP.
- In the PDP, three major feedback questions take up a central role: “Where am I now?”, “Where am I going?”, and “Where to go next?” The third has a feed-forward function.
- Most of the research available is within the educational research field only some caters for industry despite the wide use of PDP in companies as part of CDP.

Source: Clegg & Bradley, 2006; Beausaert et al 2012

Lifelong learning

- The whole PDP agenda is nested within the employability framework.

- There is considerable debate about employability and whether its focus is purely on the development of skills required by employers from graduates, and the extent to which it fits within the broader lifelong learning agenda, which in turn relates to broader conceptions of social and human capital.

- “The entire education system is designed to facilitate lifelong and ‘lifewide’ learning and the creation of formal, non-formal and informal learning opportunities for people of all ages… The concept of lifelong learning requires a paradigm shift away from the ideas of teaching and training towards those of learning, from knowledge-conveying instruction to learning for personal development and from the acquisition of special skills to broader discovery and the releasing and harnessing of creative potential. This shift is needed at all levels of education and types of provision, whether formal, non-formal or informal.”

Source: Clegg & Bradley, 2006, Coffield, 1999; UNESCO Education Strategy 2014-2021

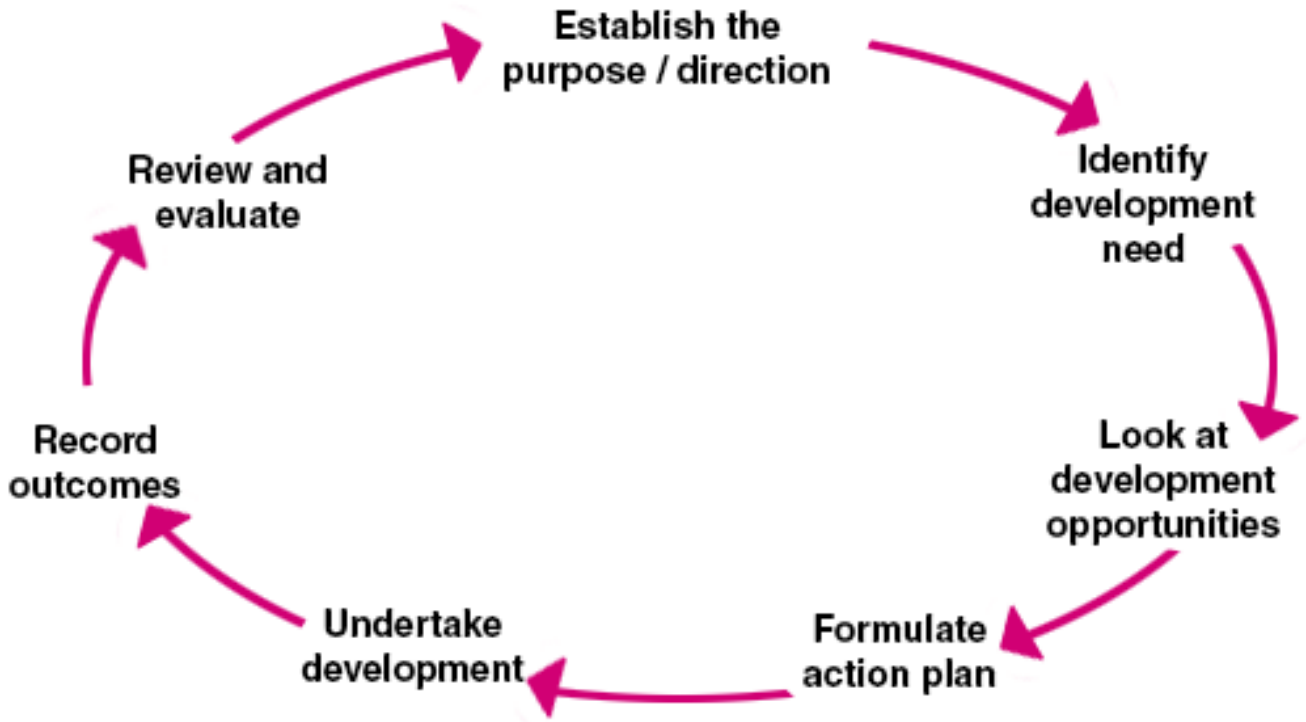
PDP by CMI

Personal development planning is the process of:

- establishing aims and objectives (or goals) - what you want to achieve or where you want to go, in the short, medium or long-term in your career
- assessing current realities
- identifying needs for skills, knowledge or competence
- selecting appropriate development activities to meet those perceived needs.

Source: Charted Management Institute

PDP by CMI



Source: Charted Management Institute

PDP by CMI

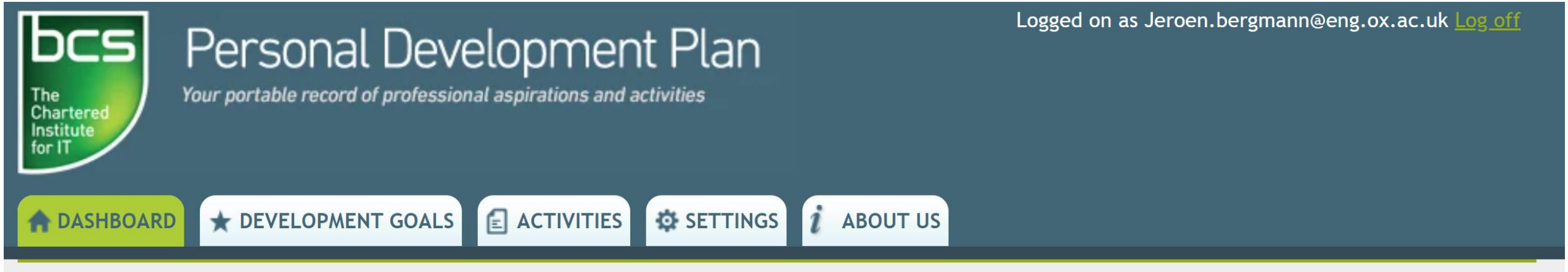
Action checklist

1. Establish your purpose or direction
2. Identify development needs
3. Identify learning opportunities
4. Formulate an action plan
5. Undertake the development
6. Record the outcomes
7. Evaluate and review

https://www.managers.org.uk/wp-content/uploads/2020/04/Personal-Development-Plan-Example-Guide.pdf

Source: Charted Management Institute

Personal Development Plan



https://pdp.bcs.org/Login?returnUrl=https%3A%2F%2Fpdp.bcs.org%2F

Name: Mr A **Department:** **Organisation:**

Date Personal Development Plan Completed:

Part 1 – Personal Analysis

Before setting your short medium and long term personal development plans, you should conduct a personal analysis: Eg - What are my strengths and weaknesses? What external opportunities or threats might affect any plans I might make?

Strengths	Areas for further development
My personal administration in the company and basic skills are good and my detailed knowledge is generally sound for my level of training. *I gained confidence from proving that I could cope with the pressures of the L and M course, even with sleep depravation. I was assessed to be composed during practical work and provided clear direction.* *Having the opportunity to lead a team over an extended period of time, I demonstrated that I have the ability to provide clear direction and manage people to achieve specific tasks whilst under pressure.*	*It was difficult to maintain the work/life balance and maintain my physical fitness standards during academic studies. As a result I have lost some physical fitness.* *I need to take more time in planning a task thoroughly before briefing my subordinates. Ie provide the solution not present the problem. My understanding of the estimate planning process is still superficial in places and requires more detail.* *In order to build my confidence in command I need more experience of team management in different scenarios*
Opportunities	**Threats**
Demonstrate to my employer that I have had both structured management and leadership training and	*Balance work and personal commitments.*

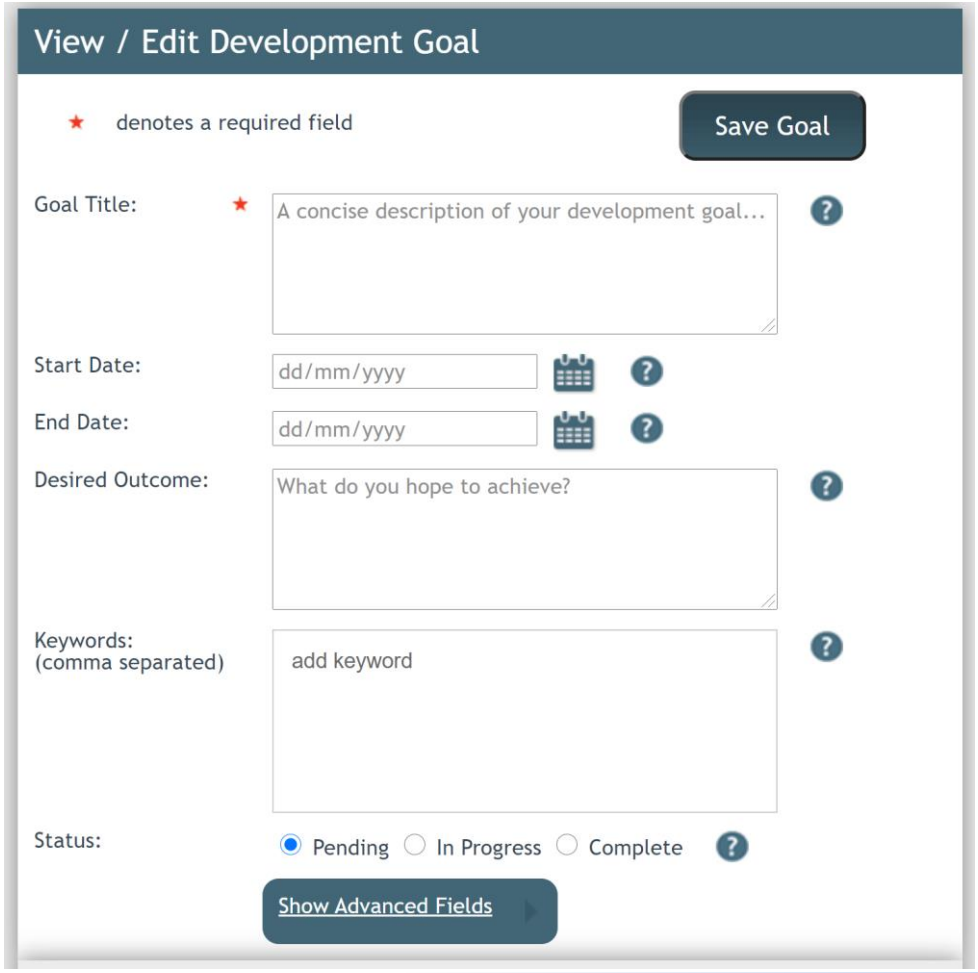
Part 2 – Setting Goals

What do I want to learn?	What do I have to do?	What support and resources will I need?	How will I measure success?	Target date for review?
Greater depth of knowledge of leading in the business external activities	Complete M and L Course (4 weekends) Training and the company Young Managers (YM) development programme	1. Regional Training Centre and YM Course Directing Staff. 2. Finding 2 weeks for the YM could be difficult.	1. Courses Assessment. 2. YM Course Assessment report. 3. Line managers Appraisal Report (LMAP) including mid-year appraisal will assess performance and potential.	Post 31 Mar report
	Get to know my department team and build their confidence and trust in me.	Advice from my Line Manager and team feedback	1. Formal and informal appraisal. 2. Self-appraisal.	Post 31 Mar report
	Identify key training opportunities in the Business Forecast of Events and de-conflict with work and social life. Because of YMs course I may not be able to engage in all business activities	I will need to discuss and agree my priorities with my Line Manager.	1. Prioritisation of goals forms part of my appraisal process. 2. Ensure that I have attended all the agreed high priority training.	Post 31 Mar report
Widen my understanding of	Learn from the more by observing experienced	Senior colleagues.	Mentoring and performance appraisal.	Post 31 Mar

Part 3 – Personal Objectives

Short Term Goals (next 12 months)
Complete Young Managers Course in order to become eligible for engagement in complex business project activities. *(I accept that some of these goals may slip into year 2 but no further).* *Have accountability for a significant cross-functional project at work.*
Medium Term Goals (next 2 – 3 years)
Be given responsibility for leading and managing a small team of in support of a challenging business project. *Engage in supporting some functions of a cross-functional project team which gives me significant business exposure.*
Longer Term Goals (beyond 3 years)
Gain promotion to middle management and gain a support of work colleagues and senior managers. *Be given responsibility for managing a large team of direct reports/ a number of teams (Work towards becoming a Head of Department).*

Goals


View / Edit Development Goal
denotes a required field
Save Goal
Goal Title:
A concise description of your development goal...
Start Date:
dd/mm/yyyy
End Date:
dd/mm/yyyy
Desired Outcome:
What do you hope to achieve?
Keywords:
(comma separated)
add keyword
Status:
Pending
In Progress
Complete
Show Advanced Fields

MPiE

Questions?

jeroen.bergmann@eng.ox.ac.uk

Management Practice

16. Value and stage-gated management

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

30/11/2020

Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to describe a stage-gated process
- Able to setup a stage-gated process
- Able to describe what happens in each stage of this kind of process
- Able to describe dFMEA
- Able to describe design controls
- Able to reflect back on the different tools available to you

Value management

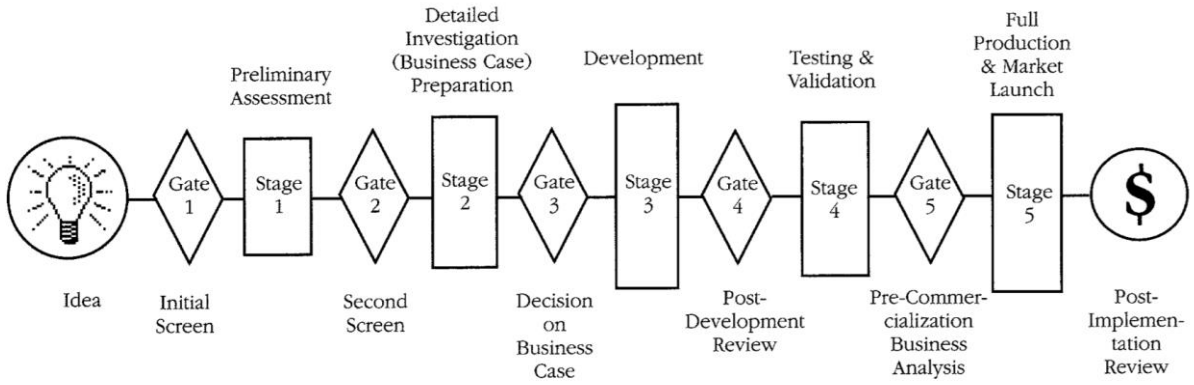
- Value Management is concerned with improving and sustaining a desirable balance between the wants and needs of stakeholders and the resources needed to satisfy them.

- This is made more challenging during the R&D process, due to the level of uncertainty.

- A gated process can be applied to support management of the process. An example of this is the product development.

Stage-gate systems

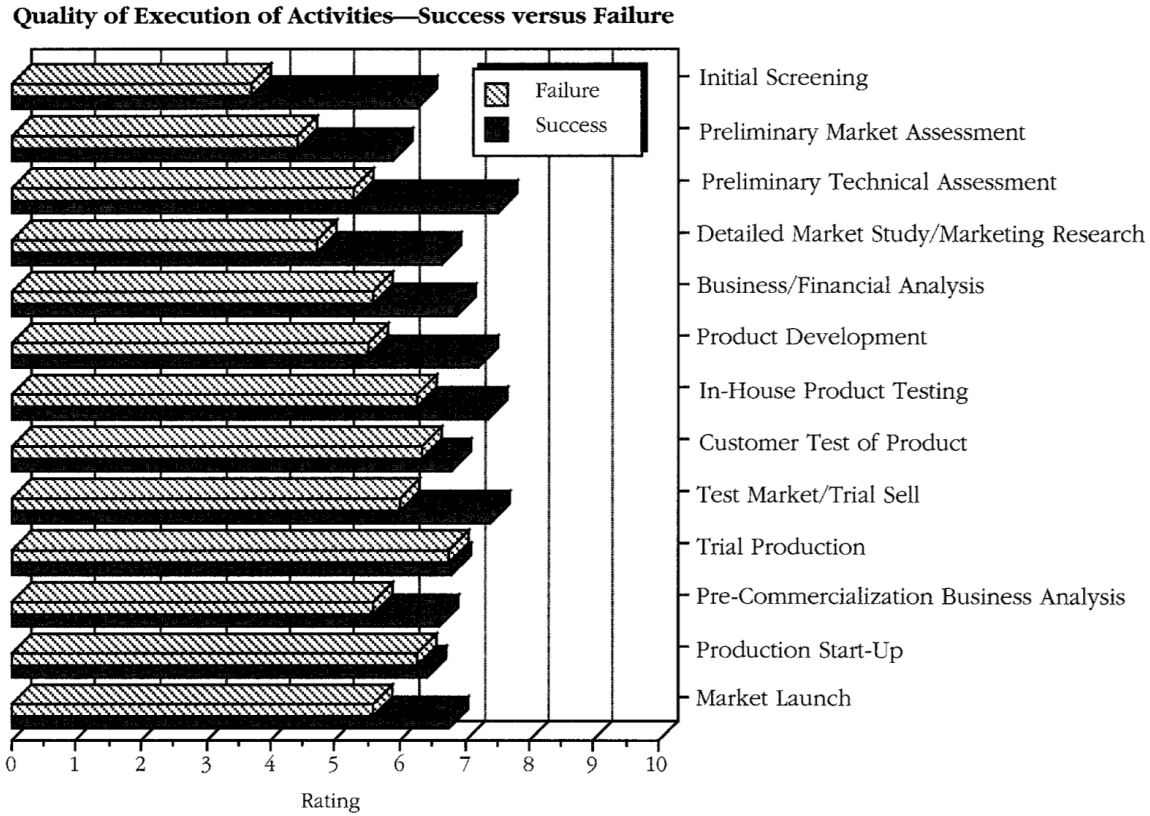
- Stage-gate systems simply apply process-management methodologies to the innovation process.
- The process is divided in a number of stages.
- A set of deliverables is specified for each gate. They need to be passed before moving to the next gate.



Source: Robert Cooper Stage-Gate Systems: A New Tool for Managing New Products 1990

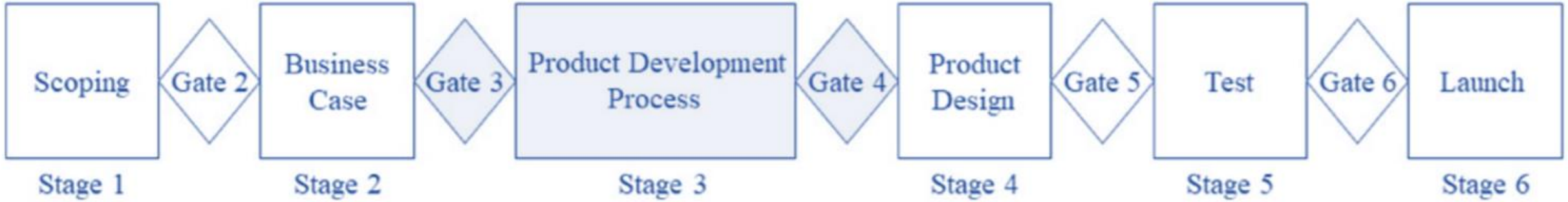
Quality as deliverable

- A research study of 203 new product projects (Cooper and Kleinschmidt 1986) suggests that quality processes are essential for new product development.
- The gates system should take into account quality of deliverables.



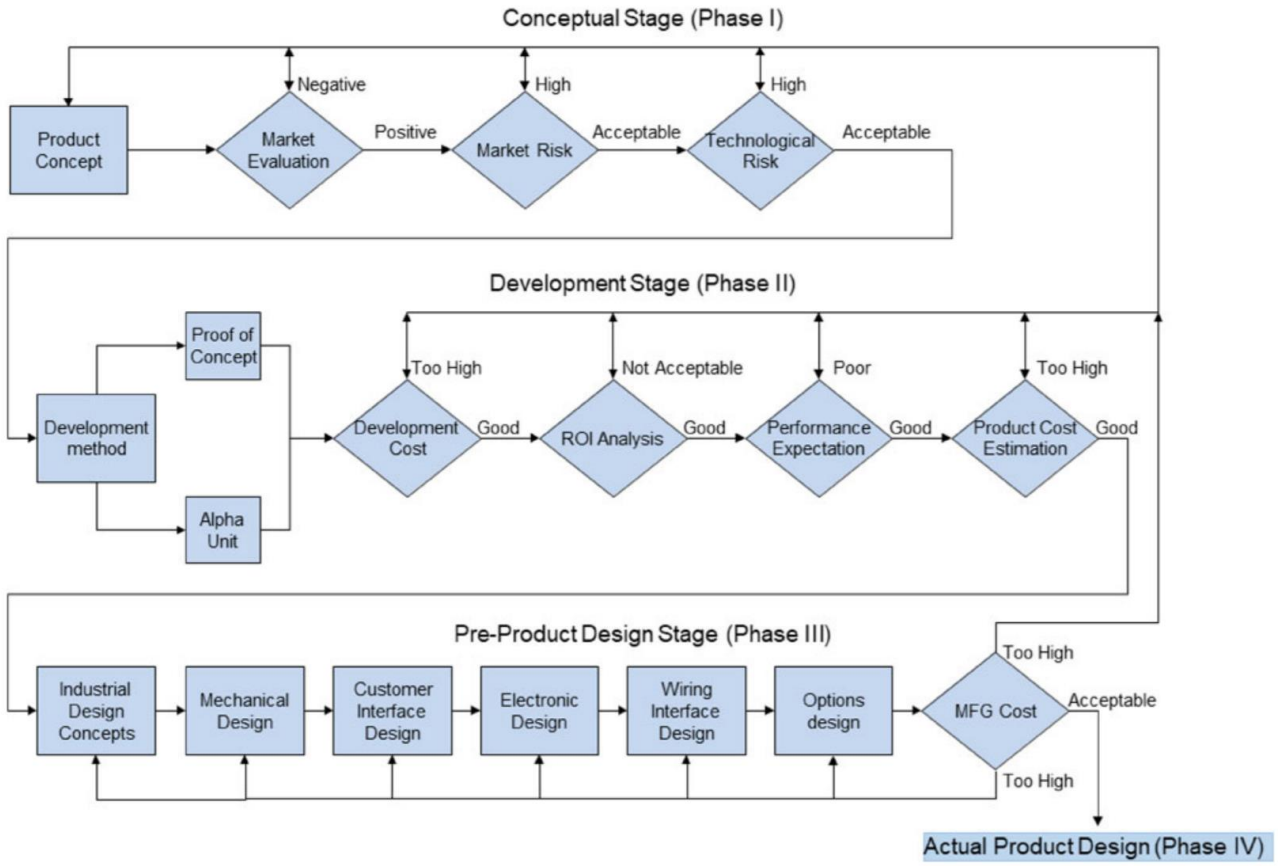
Source: Robert Cooper Stage-Gate Systems: A New Tool for Managing New Products 1990

Modified Cooper's stage-gate model



Source: JAMES MARQUIS & RUBA S. DEEB, IEEE ENGINEERING MANAGEMENT REVIEW, VOL. 46, NO. 4, FOURTH QUARTER, DECEMBER 2018

Product development



Source: JAMES MARQUIS & RUBA S. DEEB, IEEE ENGINEERING MANAGEMENT REVIEW, VOL. 46, NO. 4, FOURTH QUARTER, DECEMBER 2018

Practical stage-gated process example

- A practical overview can be provided by applying stages to the management model.

- An example will be provided to show some of the aspects of the stage-gated process.

Stage 1

Function	Stage 1 Initiation	G	Stage 2 Concept and feasibility	G	Stage 3 Design and verification	G	Stage 4 Validation and release	G	Stage 5 Post market activities
Core Development & Testing (DDT) – [part of R&D]									
Core R&D and Design	Start risk assessment (Design Failure Mode and Effect Analysis)								
Business development	Market analysis								
Regulatory	Review regulatory strategy								
Quality	Risk assessment								
Sales & Marketing									
Manufacturing									
Education and Training (E&T)	Start PDP								
Decision	Need & opportunity, feasibility, manageable risk and executional gaps								

Source: Daniel Voyce, CE marking forum 2017

Design Failure Mode and Effect Analysis (dFMEA)

Process Step	Potential Failure Mode	Potential Failure Effect	SEV[1]	Potential Causes	OCC[2]	Current Process Controls	DET[3]	RPN[4]	Action Recommended
What is the step?	In what ways can the step go wrong?	What is the impact on the customer if the failure mode is not prevented or corrected?	How severe is the effect on the customer?	What causes the step to go wrong (i.e., how could the failure mode occur)?	How frequently is the cause likely to occur?	What are the existing controls that either prevent the failure mode from occurring or detect it should it occur?	How probable is detection of the failure mode or its cause?	Risk priority number calculated as SEV x OCC x DET	What are the actions for reducing the occurrence of the cause or for improving its detection? Provide actions on all high RPNs and on severity ratings of 9 or 10.
ATM Pin Authentication	Unauthorized access	• Unauthorized cash withdrawal • Very dissatisfied customer	8	Lost or stolen ATM card	3	Block ATM card after three failed authentication attempts	3	72	
	Authentication failure	Annoyed customer	3	Network failure	5	Install load balancer to distribute workload across network links	5	75	
Dispense Cash	Cash not disbursed	Dissatisfied customer	7	ATM out of cash	7	Internal alert of low cash in ATM	4	196	Increase minimum cash threshold limit of heavily used ATMs to prevent out-of-cash instances
	Account debited but no cash disbursed	Very dissatisfied customer	8	• Transaction failure • Network issue	3	Install load balancer to distribute workload across network links	4	96	
	Extra cash dispensed	Bank loses money	8	• Bills stuck to each other • Bills stacked incorrectly	2	Verification while loading cash in ATM	3	48	

1. **Severity**: Severity of impact of failure event. It is scored on a scale of 1 to 10. A high score is assigned to high-impact events while a low score is assigned to low-impact events.
2. **Occurrence**: Frequency of occurrence of failure event. It is scored on a scale of 1 to 10. A high score is assigned to frequently occurring events while events with low occurrence are assigned a low score.
3. **Detection**: Ability of process control to detect the occurrence of failure events. It is scored on a scale of 1 to 10. A failure event that can be easily detected by the process control is assigned a low score while a high score is assigned to an inconspicuous event.
4. **Risk priority number**: The overall risk score of an event. It is calculated by multiplying the scores for severity, occurrence and detection. An event with a high RPN demands immediate attention while events with lower RPNs are less risky.

Source: isixsigma

	Stage 1
Deliverables and Key Tasks	Market Report – needs assessment; competitive analysis; SWOT; business opportunity
	Financial forecast and reimbursement strategy
	Investor relations
	Legal and IP analysis
	Technical risks and start development plan
	Regulatory plan and clinical path
	Overall business strategy
Decisions at Gate 1	Is there a market opportunity?
	Are regulatory and IP risks acceptable?
	Are the classification and essential requirements understood?
	Is the project feasible?

Source: Daniel Voyce, CE marking forum 2017

Function	Stage 1 Initiation	G	Stage 2 Concept and feasibility	G	Stage 3 Design and verification	G	Stage 4 Validation and release	G	Stage 5 Post market activities
Core Development & Testing (DDT) – [part of R&D]			Core team formation, project plan and timeline						
Core R&D and Design	Start risk assessment (Design Failure Mode and Effect Analysis)		Prototype design, dFMEA, initiate design history file (DHF) , manufacturability						
Business development	Market analysis		Business plan and strategy						
Regulatory	Review regulatory strategy		Prototype analysis, initiate regulatory strategy						
Quality	Risk assessment		Supplier and supply chain evaluation,						
Sales & Marketing									
Manufacturing			Review manufacturability						
Education and Training (E&T)	Start PDP		PDP						
Decision	Need & opportunity, feasibility, manageable risk and executional gaps		Value proposition, product risk, acceptance, feasibility, manufacturing & supply						

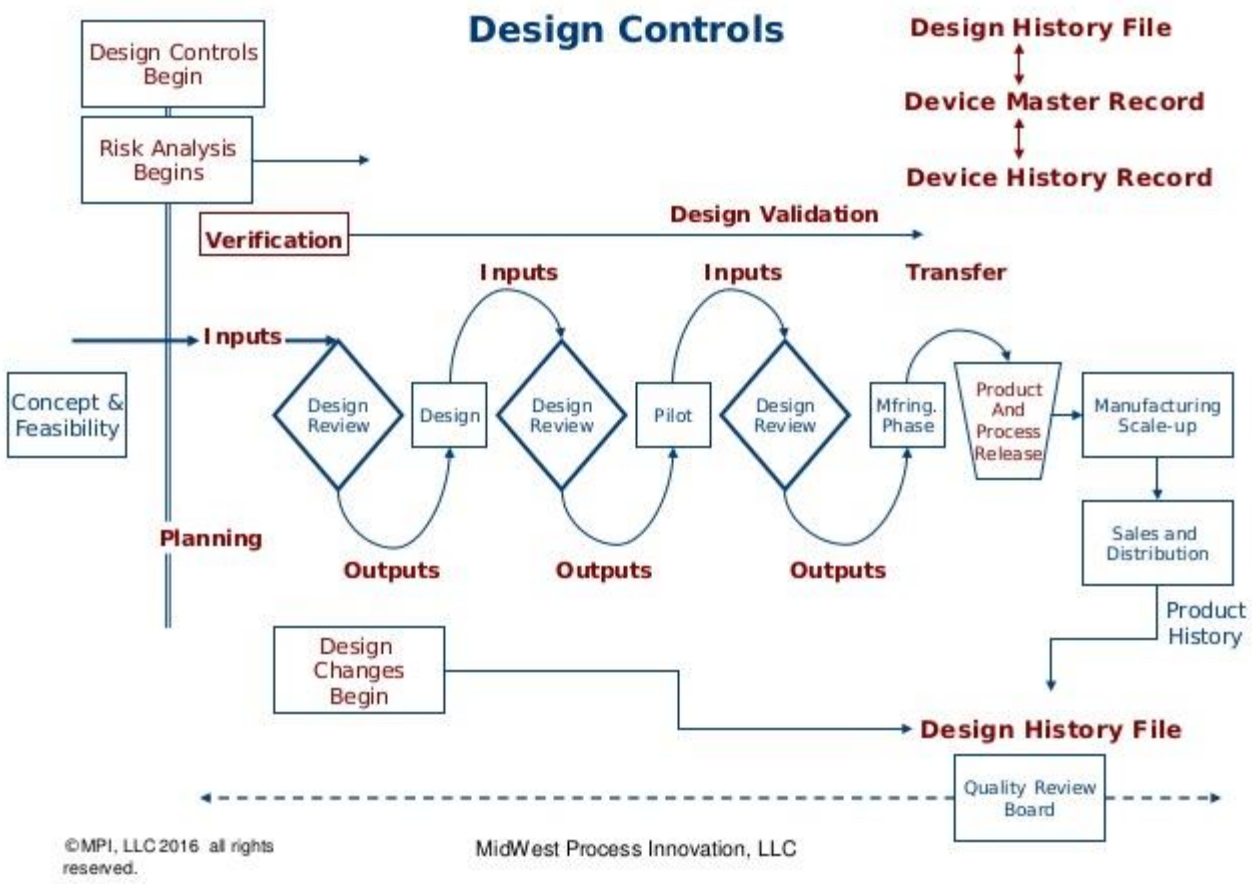
Design history file

- Information concerning intermediate design models, decision steps and the overall reasoning process are part of the 'design history' file.

- Design history files help:
  - explain how and why certain design decisions were made
  - verify that a product meets its specification is facilitated
  - explain how design changes might effect the specifications
  - the reuse of old design solutions

Source: JOHAN MALMQVIST (1997) Improved Function-means Trees by Inclusion of Design History Information, Journal of Engeering Design, 8:2, 107-117,

Design History File as part of control

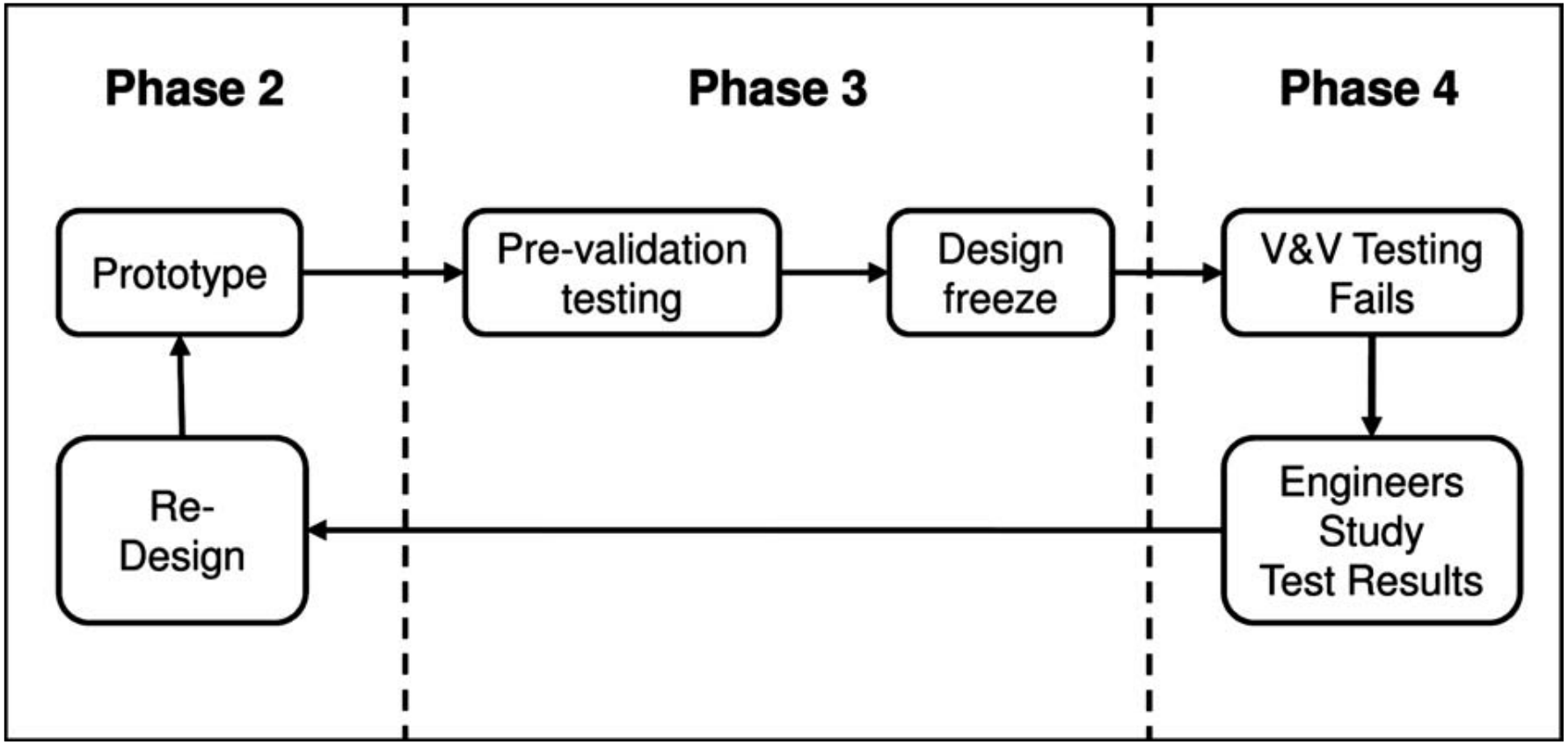


	Stage 2
Deliverables and Key Tasks	Identification of CORE design and development team members
	Approval of project timelines
	Design inputs and target specification
	Initial regulatory plan & Design History File started
	Design review - prototype design and evaluation
	Initial design risk analysis assessment
	Design for manufacture and supply chain evaluation
Decisions at Gate 2	Value proposition acceptable?
	Product risks acceptable?
	Manufacturing supply chain established?
	Proof of Concept demonstrated?

Function	Stage 1 Initiation	G	Stage 2 Concept and feasibility	G	Stage 3 Design and verification	G	Stage 4 Validation and release	G	Stage 5 Post market activities
Core Development & Testing (DDT) – [part of R&D]			Core team formation, project plan and timeline		Finalise specification and verify plan, validation plan				
Core R&D and Design	Start risk assessment (Design Failure Mode and Effect Analysis)		Prototype design, dFMEA, initiate design history file (DHF) ,		Product verification, DHF				
Business development	Market analysis		Business plan and strategy		Business plan				
Regulatory	Review regulatory strategy		Prototype analysis, initiate regulatory strategy		Review design and risk, documentation				
Quality	Risk assessment		Supplier and supply chain evaluation,		Supplier approval				
Sales & Marketing					Sales and costumer strategy				
Manufacturing			Review manufacturability		Process risk				
Education and Training (E&T)	Start PDP		PDP		PDP				
Decision	Need & opportunity, feasibility, manageable risk and executional gaps		Value proposition, product risk, acceptance, feasibility, manufacturing & supply		Design freeze, verification report, risk mitigation, supplier approval, regulatory submission				

	Stage 3
Deliverables and Key Tasks	Finalised *PRS* - Performance Requirements Specifications, *SRS* - System Requirement Specifications, FRS - Functional Requirement Specifications, Uniform Replication Strategy (*URS*)
	Detailed designs completed
	Design risk analysis assessment updated
	Initial regulatory plan
	Verification plans, tests and reports completed
	Quality and process validation plans created
	Validation plan
Decisions at Gate 3	Design outputs satisfy inputs?
	Product risks acceptable?
	Design is ready to be frozen?
	Device is ready for regulatory submission?
	Supply chain approvals complete?

Handle of failures



Source: Jan B. Pietzsch et al, 2009

Function	Stage 1 Initiation	G	Stage 2 Concept and feasibility	G	Stage 3 Design and verification	G	Stage 4 Validation and release	G	Stage 5 Post market activities
Core Development & Testing (DDT) – [part of R&D]			Core team formation, project plan and timeline		Finalise specification and verify plan, validation plan		Product validation		
Core R&D and Design	Start risk assessment (Design Failure Mode and Effect Analysis)		Prototype design, dFMEA, initiate design history file (DHF) ,		Product verification, DHF		Technical support of testing		
Business development	Market analysis		Business plan and strategy		Business plan		Branding and marketing launch, negotiations		
Regulatory	Review regulatory strategy		Prototype analysis, initiate regulatory strategy		Review design and risk, documentation		Prepare regulatory submission		
Quality	Risk assessment		Supplier and supply chain evaluation,		Supplier approval		Process qualification, expire date testing, product life		
Sales & Marketing					Sales and costumer strategy		Sales and costumer support setup		
Manufacturing			Review manufacturability		Process risk		Scale up production		
Education and Training (E&T)	Start PDP		PDP		PDP		PDP – training of sales employees		
Decision	Need & opportunity, feasibility, manageable risk and executional gaps		Value proposition, product risk, acceptance, feasibility, manufacturing & supply		Design freeze, verification report, risk mitigation, supplier approval, regulatory submission		Evaluation report, launch plan, manufacturing process, post market plan		

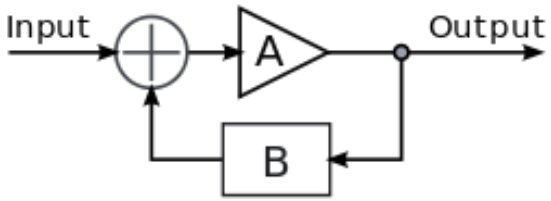
	Phase 4
Deliverables and Key Tasks	Product validation complete
	Process risk complete, Manufacturing scale-up
	Design risk analysis assessment updated and reviewed.
	Risk management plan updated
	Product branding and literature Sales and marketing launch planned
	Revenue strategy finalised
Decisions at Gate 4	Device conforms to users requirements and intended use?
	Device is ready to be cleared for from a regulatory perspective? CE Submission complete?
	Design transfer complete?

Management Practice in Engineering

MPiE

- A range of tools have been introduced and discussed.
- You will have to make decisions on (incomplete) best evidence for the selection of tools in a given situation.
- Make use of the background information provided and see if the problem can be seen as a system (of systems).

Feedback



MPiE

Questions?

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