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Constitution of an

Agile Project Management Framework

Managing Internet of Things Innovations

at *ITAB Shop Concept Finland Oy*

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Abstract
The fourth industrial revolution, the so-called *digital transformation*, shows its impact on a wide range of industries. Next to big data, the *Internet of Things* is one of the main drivers of digitalizing industrial processes and products as well as consumer applications. The companies, which are situated in the affected industries, therefore, have to adapt to upcoming changes due to the requirement of new competencies, internal processes and a digitalization of the product portfolio.
Offering these companies a foundation for resisting the change, an agile project management framework was assumed as the right approach to cope with the digitalization impacts. Investigating into this key assumption's value as well as building a base for a framework's constitution, the Internet of Things was researched and analysed resulting in development requirements and challenges. In subsequence, the agile project management was examined based on Scrum, the Dynamic Systems Development Method and Kanban as three agile representatives. Contrasting it to traditional management to derive advantages and disadvantages of the alternative approach; agile project management was matched to the development requirements and challenges of Internet of Things. As a result of this alignment, a basic theoretical framework was constituted. Hereafter, the current circumstances by the affected, exemplary retail and shop fittings industries were approached to provide additional characteristics for the framework. For that purpose, the representative company *ITAB Shop Concept Finland* was examined by conducting a situation analysis. Besides process design workshops; the conduction was performed by employee interviews, a SWOT analysis as well as an internal benchmarking. Based on the completed framework's application – consisting of chosen agile values and principles, practices and process phases – to a development project of the SMART FITTINGS™ department, a general positive impact was recognized. Next to improving the company's and team's communication and collaboration, the resource efficiency was increased by reviewing the project's outcome on an iterative and regular basis leading to a faster responding to changes. Nevertheless, the implementation amount was insufficient to verify agile project management as the right approach to cope with the impact of the digital transformation and Internet of Things innovations. On that account, the framework's implementation in further development projects as well as a consideration of further agile or non-agile project management approaches is required.

Keywords/tags
Agile project management, digital transformation, Dynamic Systems Development Method, framework, Internet of Things, *ITAB Shop Concept Finland*, Kanban, Scrum, SMART FITTINGS™

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Abbreviations and Acronyms

API	application programming interface
APM	agile project management
B2B	business-to-business
ca.	circa
CCTV	closed circuit television
CIA	confidentiality, integrity, availability
DSDM	Dynamic Systems Development Method
EAN	European Article Number
e-commerce	electronic commerce
e.g.	exempli gratia
EPC*	event-driven process chain (*starting with chapter 4)
EPC (Gen II)	Electronic Product Code (Generation II)
EPCIS	Electronic Product Code Information System
ERP	enterprise resource planning system
EU-28	European Union (28 member states)
FIFO	first in - first out
fig.	figure
GDP	gross domestic product
GHz	gigahertz
HF	high frequency
HR	human resources
HSE	health, safety and environment
HTTP	hypertext transfer protocol
INVEST (acronym)	independent, negotiable, valuable, estimable, small, testable
ID	identification (Auto-ID)
IDC	International Data Corporation
IEEE	Institute of Electrical and Electronics Engineers
(I)IoT	(Industrial) Internet of Things
IP (v4/6)	internet protocol (version 4/6)

IT	information technology
ITAB SCF	ITAB Shop Concept Finland Oy
JIIP	Joint Institute for Innovation Policy
LH	low frequency
MHz	megahertz
MQTT	message queue telemetry transport
MoSCoW	must Have, should have, could Have, won't Have
NDEF	near field communication data exchange format
NFC	near field communication
no.	number
ONS	Object Name Service
POE	point of engagement
POS	point of sale
PRL	Prioritized Requirement List
RAD	Rapid Application Development
R&D	research and development
RF/RFID	radio frequency/ radio-frequency identification
SFAPMF	SMART FITTINGS™ Agile Project Management Framework
TID	Tag Identifier
TLS	transportation layer security
UCC	Uniform Code Council
UHF	ultra-high frequency
US	United States (of America)
VCD	value-added chain diagram
vs.	versus
WiFi	Wireless Fidelity
WIP	work in progress
WSN	wireless sensor network
WSAN	wireless sensor and actuator network
XOR	exclusive or

1 Introduction

These days, the economy as well as the society are facing the impacts of the designated fourth industrial revolution (Becker, Knop 2015, 1; Schwab 2016, 1). The so-called *digital transformation* (World Economic Forum, Accenture (Eds.) 2016, 6–7) is the initiator for a research, which examines its effects on chosen industries as well as provides solutions to take advantage of the change. In the following, the background, objectives and a structure for this subsequent research are defined.

1.1 Initial Situation

Different kinds of industries are facing a digital change. Whereas the mobility sector becomes digitally connected enabling autonomous transportation; logistics companies investigate drones and robots to make processes more efficient. Additionally, global brands in the sector of consumer goods, like *Amazon* or *Apple*, develop digital, for instance, voice-controlled assistants which are capable of choosing fitting clothes for the user, playing their favourite song or ordering certain items automatically. These innovations lead to the transformation of industrial processes, but also of processes for the usage of everyday solutions such as the exemplary shopping flow. Next to unlimited opening hours, product reviews and item comparisons are two of the changes of the usage flow in contrast to the process in traditional retail stores. Implying an advantage for customers, online shops are able to increase their significance to the disadvantage of the stationary retail. As a consequence, retailers have to react on the change being able to prevent store closings, which result from a decreasing amount of customers and a consequent reduction of revenues.

Dealing with "digitalization in retail, the 2017 EuroShop fair in Düsseldorf exhibited two main strategies to reduce the impact as well as taking advantage of the "digital disruption" (ibid., 4):

1. **Making processes more efficient:**

Since the revenues of offline stores decrease, the underlying processes have to be performed more efficiently to increase the profitability of the stores. Whereas store processes, e.g., inventory management can become more efficient by utilizing auto-

nomous drones or robots, also the shopping processes for customers are approached. As an exemplary solution, the Swedish *ITAB Group* presented their cashier-free shopping flow *AirFlow* to prevent shoppers from waiting times in cashier queues.

2. **Improving the shopping experience:**

Being able to cope with the e-commerce's advantage of individually approaching the customer, the shopping experience within a brick-and-mortar store is adapted. Next to digital solutions enabling a connection between both channels, the interactivity between the store and the customer is focused. For that purpose, gesture or touch-enabled products signify an upcoming trend. Besides, robots were demonstrated which are able to actively communicate and interact with customers.

Both trends lead to the digital transformation in the retail industry and are based on certain technologies. One of them is the so-called *Internet of Things* (Schwab 2016, 1). Due to the extended integration of the Internet and the underlying data, retail shops have to adapt their processes and competencies. The same applies to the technology providers arriving from different origins. One of them is the shop fitting industry, which was previously focusing on basic products like "analogue" shelving and storage systems. Being able to resist the digital transformation in their costumer's industry, they have to adapt their product portfolio enabling the change for the retail shops. This implies, next to current difficulties such as price pressure, the occurrence of new challenges. Next to upcoming, new business fields, also new processes and competencies have to be adopted within the companies.

1.2   Research Objectives

Companies from differing industries are confronted with these challenges. Nonetheless, the broached retail and the related shop fitting industry, therefore, act as a reference industry during the following research. Both industries should provide a research foundation, on which the challenges and effects of Internet of Things as a consequence of the digital transformation are going to be analysed.

With the objective of providing affected companies a solution to encounter the challenges and effects, this research has the intention to derive requirements for a project management solution, which shall be applicable to the product development.

For this purpose, the following key assumption was alleged providing a guiding threat for both the bachelor thesis and its related scientific project:

"The **Internet of Things** entails a **transformation pursuit**; wherefore **agile project management** provides the right **foundation** for the **constitution** of a project management **framework**."

The research can accomplish its intention by either corroborating or discounting this key assumption. Nevertheless, agile artefacts of certain agile project management approaches shall be identified to provide requirements for the constitution of a project management framework. During the scientific project, another goal of subsequently applying the framework to an Internet of Things development project is pursued. Taking *ITAB Shop Concept Finland Oy* as the host company, the framework's impacts on the challenges and effects of the digital transformation are evaluated.

1.3   Research Design

During the bachelor thesis, a theoretical foundation is created making it able to corroborate or discount the alleged key assumption. For this purpose, the Internet of Things is, at first, described by answering the following research questions:

- **What** is the **Internet of Things**?
- **What** is the **impact** of **RFID** on the **Internet of Things** and the **retail industry**?
- **What** are the **requirements** and **challenges** for the **development** of **Internet of Things innovations**?

In subsequence, agile project management approaches are analysed and confronted with traditional project management to examine its capability of responding to a change. For this coherence, certain questions are answered:

- **How agility** is **created** in **agile project management** approaches?
- **Which** of the **approaches** or what **parts** can be **used** to **counter IoT-challenges**?

At the end of the bachelor thesis, both theoretical parts are combined by confronting best practices of Internet of Things development solutions to the agile project management approaches. In the case of identifying a certain relation, first requirements for a theoretical project management framework are created.

During the scientific projects, the actual state of *ITAB Shop Concept Finland* is analysed with the intention of identifying further requirements for the framework. After its construction, it is applied to an Internet of Things development project. During its performance, the framework and its artefacts are evaluated to draw conclusions about its impact and verify its functionality.

2   Internet of Things (IoT)

Each of the products and solutions, mentioned in the introduction, is enabled by the usage of gathered data. Without its location, digital assistants like *Amazon's Alexa* wouldn't be able to choose the right song. The same applies to drones, which couldn't deliver a parcel to the right receiver without knowing the right address. Both are examples, wherefore experts, like the former *SAP* CEO Henning Kagermann, see Internet of Things due to its "data integration", "storage" and "analysis" capabilities (Bucher 2017) as the reason and a key driver for the digital transformation (Andelfinger, Hänisch 2015, 10). Public institutions acknowledge this opinion. Whereas the *European Union's* parliament attributes it as a social and economic daily life changer (ibid.), the *US National Intelligence Council* sees IoT as one of the six "Disruptive Civil Technologies" able to cause an impact on the national power (National Intelligence Council (NIC) (Ed.) 2008, i). Being able to understand this disruptive technology, IoT's origin and structure have to be examined.

2.1   Definition

The concept of objects consisting of a computer to process data and reacting based on it, originates from Mark Weiser, who was a scientist at *Xerox PARC* during the 1990s. His vision was named "ubiquitous computing", which referred, in especially, to everyday products. (McEwen, Cassimally 2014, 22)

In 1999, Kevin Ashton, an employee of *Proctor & Gamble* (Ashton 2015, 13), modified this concept by adding an Internet connection to it (McEwen, Cassimally 2014, 10). Therefore, he implemented a microchip into a lipstick making it visible for a computer by sending the data via and storing it in the Internet (Ashton 2015, 13). To gain the attention of the management and make it understandable, Ashton designated his later patented "Storage System" as "Internet of Things" (ibid.).

The *Oxford Dictionary* added Ashton's term in 2013, defining it as an ".. interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data" (Oxford University Press (Ed.) N.d.a). Although Mukhoadhyay and Suryadevara (2014, 1) share that understanding of IoT as "... embedded devices (things) with Internet connectivity, allowing them to interact with

each other, services, and people on a global scale"; Ashton delivers a deferring view on his term. Claiming that it is misunderstood, his original definition questioned the quality of data being stored on computers and in the Internet due to its human origin and implementation. With an Internet based on data that "things" are collecting, he has the vision of improving the data's accuracy and increasing the Internet's efficiency by data being directly and automatically captured by sensors or *RFID*. (Ashton 2009)

2.2   Architecture of IoT Systems

Getting an understanding about how things fill the Internet with data, the IoT structure has to be viewed in detail. Analysing the understandings of authors like McEwen, Cassimally (2014, 11) and Rowland et al. (2015, 10), a typical IoT system consists of three components: a physical object, electronics and the Internet. The electronic components can be moreover divided into controllers, sensors and actuators (McEwen, Cassimally 2014, 11). Whereas the sensors make the things "aware" (Baumgartner, Mlynarski 2017) of their environment by converting external energy input into numeric values, the actuators are able to perform actions enabled by certain digital instructions (Rowland et al. 2015, 48). These instructions, also known as triggers, are consequently translated into mechanic actions (ibid., 52). Both the sensing and the related performing are processed by microcontrollers, which function as a physical device's engine (McEwen, Cassimally 2014, 94). Additional components that connect the thing to the Internet by sending and analysing the data "autonomously" (Baumgartner, Mlynarski 2017) to enable the trigger, however, are not included in the general IoT equation by McEwen and Cassimally (2014, 11). Offering the bridging function of sensors and actuators to connect the physical world and the Internet (Rowland et al. 2015, 48), also *Wireless Sensor Networks* (WSNs), or *Wireless Sensor and Actuator Networks* (WSANs) respectively, have to be considered as an essential part of IoT systems.

Illustrating a WSAN, figure 1 shows that data which is ascertained by sensor nodes is collected at a sink node sending it to the Internet via a gateway. Arriving there, other processing powers are used to analyse the informational input. Since not all sensors

have an own IP address, gateways are necessary to be interposed. Functioning as proxies, they enable a communication between the Internet and the things due to the translation of Internet-based communication protocols, e.g., from broadband routers (ibid., 67) to a differing thing protocol. (Delicato et al. 2013, 6) For consumer purposes, these gateways are also called hubs or bridges. They can also be replaced with phones, e.g. for the usage of smart wearables, or with a direct WiFi or cellular connection between a thing and the Internet (Rowland et al. 2015, 66–69).
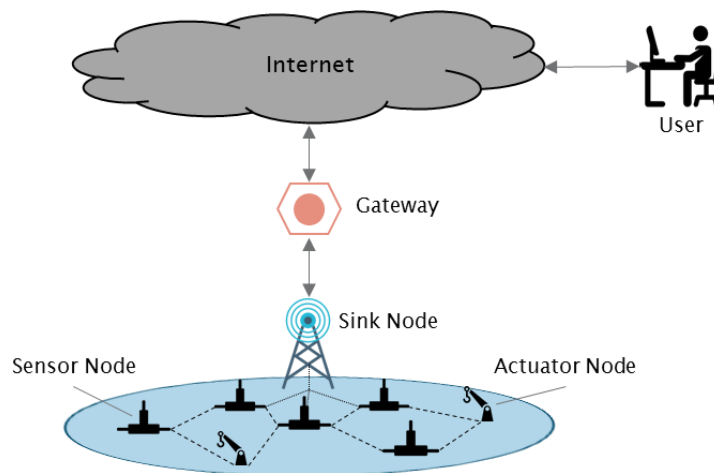
Figure 1. Wireless Sensor and Actuator Network (WSAN)
(adapted: (Delicato et al. 2013, 6))

One of the reasons, why things don't use Internet communication protocols are their energy constraints. Since many of the things are battery-powered, their energy consumption has to be limited enabling a long lifetime. Typically, used Internet application protocols like *HTTP* (see Appendix A.1) , however, require a huge amount of electrical power reasoned with their data package size (ibid., 91), making them unsuitable for edge devices (things). (ibid., 72) Thus, communication protocols such as *Bluetooth* and *Zig Bee* are commonly used. The latter one, a low-powered radio network, increases its suitability, compared to *Bluetooth*, due to a longer range created by *mesh networking*. (ibid., 80–82) This networking principle, which is illustrated in figure 1, increases the range by sending the data from *Zig Bee* devices not directly to the gateway or the sink node, but to the closest device till the collection point is reached (Andelfinger, Hänisch 2015, 21). Another method eliminating the issue of a too high power consumption and often used for IoT solutions is RFID, which will be described in chapter 2.2.2 (Rowland et al. 2015, 83).

Even though gateways can be used for higher processing operations as well as for the encryption and decryption of data, which make a simpler architecture of things possible, they pose the risk of failure as all communication transaction have to pass it (ibid., 74). Furthermore, gateways limit the functions of their things, which could be extended by giving each thing an own IP address. Enabling a direct communication from the Internet to the devices and releasing the whole potential of IoT, a new protocol has to be developed handling the power constraints as well as being based on IP. One approach, the so-called *Thread*, is a new standard protocol, which is currently in development by a consortium including companies like *Nest* and *Samsung*. It is based on the new IP address standard IPv6. The former one, IPv4, was too limited by having space for only four billion addresses. Considering the forecasted amount of things in the future, this amount isn't sufficient. (ibid., 85–86)

2.2.1 Web of Things (WoT) and Middleware Platforms

Due to the variation of sensors and actuators in addition to their communication methods, the development of IoT applications becomes complex (Delicato et al. 2013, v). The simplification of the development of an exemplary application, which is able to control the light through an app, can be achieved with the connection of things not only to the Internet layer via IP, but also to the application layer, which allows the communication between computer processes (Rowland et al. 2015, 76).
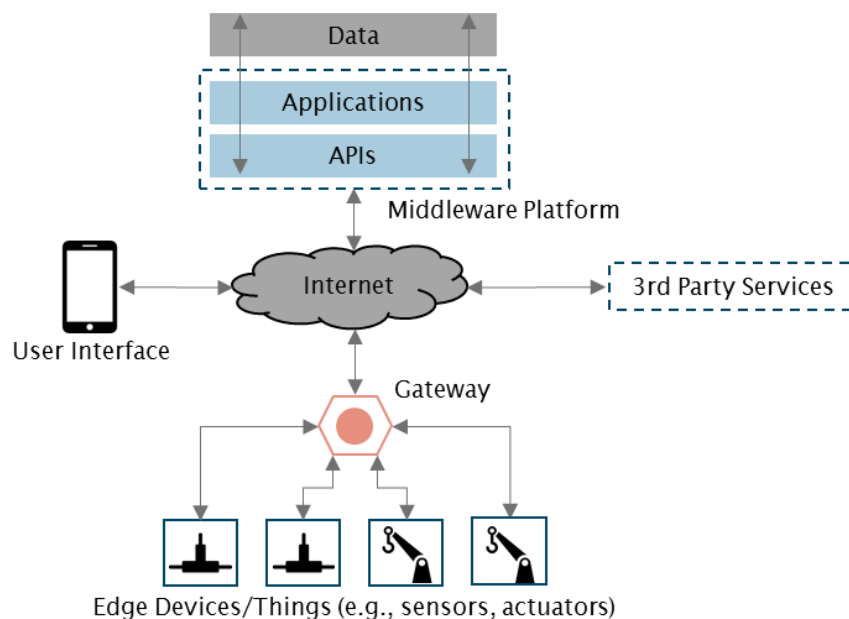
Figure 2. IoT architecture with Web of Things applications
(based on: (Rowland et al. 2015, 67))

Due to the *World Wide Web* being located on the application layer (see Appendix A.1), this extension of the IoT architecture is called *Web of Things*. Based on the usage of application protocols like *HTTP* or MQTT (ibid.), things can be identified likewise other Web resources, and are consequently made "… addressable, .., controllable, and accessible…" (Delicato et al. 2013, 6). The latter protocol, *MQTT* (Rowland et al. 2015, 91), was exclusively created by *IBM* as a lightweight approach for IoT applications (McEwen, Cassimally 2014, 203). Being an open standard (ibid.), it is able to emit smaller data packages as well as transferring them efficiently through low-power device networks. This results from the usage of a *publish-subscribe network* (see appendix A.1) in which interested devices can subscribe to topics from a central messaging server. *HTTP*, in contrast, requires a direct connection to the message receiver. (Rowland et al. 2015, 91–92) Both, nonetheless, can be encrypted and secured with the *Transport Layer Security* (TLS), which is, for example, used in *HTTPS*-based online payment transactions (Obermaier 2017).

Since differing IoT devices are as easy to find and access as webpages, their application development becomes easier, too (Delicato et al. 2013, 9). As figure 2 shows, the applications which process sensor data or trigger actuator performances are usually build on *middleware platforms* (Rowland et al. 2015, 93–94). Other names are "WSN platforms*"* (Song et al. 2014, 75) or "IoT platforms*" (Pérez, Bernardos Barbolla 2014, 29)*. Providing a service to the user, Delicato and colleagues (2013, 10) emphasize an integration of devices with different kinds of protocols and components as one of the essential functions of middleware platforms and, therefore, refers to Mattern and colleagues (2010, 248). Furthermore, they have to ensure the data security and privacy, which are described in chapter 2.4, as well as the processing of a big amount of collected data. (ibid., 248–249)

Another element of IoT platforms are a*pplication programming interfaces*, short APIs. They allow the access to data and other functions of a device. Mobile applications or other services, hence; initiate an additional value (Rowland et al. 2015, 94). These also called *physical mashups* (Guinard et al. 2009a, 196) can add value to a light bulb of a smart home system by not just making it addressable in the Web, but to make it accessible via APIs by a mobile app controlling several smart home devices.

2.2.2 Influence of Radio-frequency Identification (RFID) on IoT

Next to Wireless Sensor and Actuator Networks, RFID plays an important role for the success and the wide distribution of Internet of Things. Song and others (2014, 76) entitle the *Radio-frequency Identification* technology as a key enabler due to its utilization in the first IoT solution by Kevin Ashton. With its sensing, identifying, communicating, locating, tracking functions (Duroc, Andia Vera 2014, 234); RFID is able to extend the range of connected things to passive objects (Mattern 2005, 56) like clothes or metal parts as well as showing information about performed processes in the digital world (Siemens AG, PR RFID (Eds.) 2017). Song and colleagues (2014, 76) and Maney (2013), therefore, describe the concept of nearly everything communicating to the Internet as well as with each other as step to the *Internet of Everything*.

Based on Heinrich Hertz's detection of electromagnetic waves and their first application in an RFID solution during the Second World War (Brown 2000, 21), the technology is today researched, among others, in *Auto-ID* Labs at renowned universities (Miles 2008, 1–5). Analysing the technological function principles, Glover and Bhatt (2006, 21) claim that there is not a general RFID architecture fulfilling every possible function. However, they detect, just as Tamm and Tribowski (2010, 13) as well as Sarma (2008, 17), three main components of an RFID system: the *tag*, the *reader* and the RFID information system.
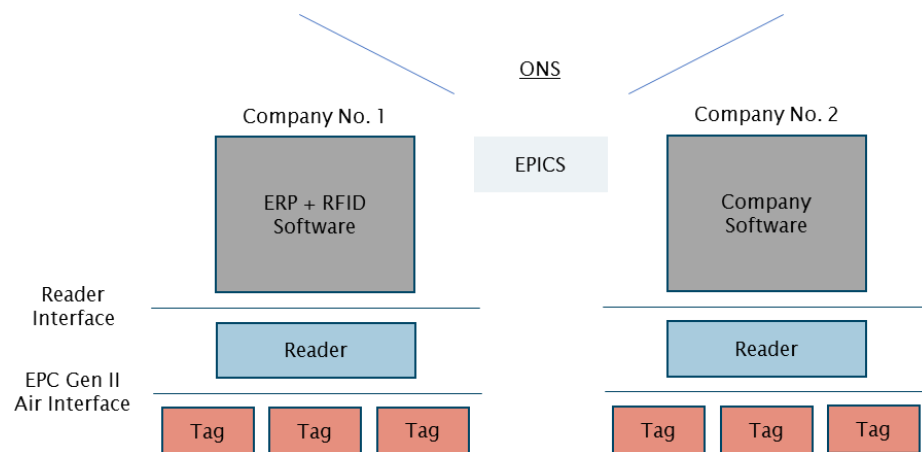
Figure 3. EPCglobal RFID architecture
(adapted: (Sarma 2008, 17))

Illustrating a standardized architecture by the *EPCglobal* institution, figure 3 points out the RFID tag as base of the whole RFID system (ibid., 16–17). These tags or tran-

sponders (Scholz-Reiter et al. 2008, 186) establish an object's unique identity by storing its data digitally while being physically attached to it (Glover, Bhatt 2006, 55). Every chip consists of a coil or antenna (ibid.), which is able to receive radio frequencies in order to reflect it for the purpose of sending the tag's data to the reader (ibid., 34). The optional microchip or internal circuit with its integrated memory is capable of storing and securing data (atlasRFIDstore.com (Ed.) 2017; Glover, Bhatt 2006, 71). Nonetheless, they can have different sizes, shapes and housings, which are dependent on the usage circumstances (Glover, Bhatt 2006, 57). The RFID tag in figure 4, for instance, consists of an internal circuit, an antenna and a foundation paper layer is usable, among others, for supply chain management or timing applications (atlasRFIDstore.com (Ed.) 2017).

The storage function has to be differentiated due to the availability of different kinds of memories. The *reserved memory* stores the access and kill password, of which the latter one is used to put the tag out of order. The *EPC memory stores* the product's code, whereas the *TID memory* stores the unique manufacturing and identification code of the tag. The fourth memory type is the *user memory*, which is likewise the EPC memory, and in rare cases the reserved memory, writable. (GS1 2017, 58)

Figure 4. Exemplary SMARTRAC Dogbone RFID paper tag
(atlasRFIDstore.com (Ed.) 2017)

Filling the EPC memory, the *Electronic Product Code* was created by the *EPCglobal* joint venture, which was formed in the year 2003 from *GS1* (former *EAN International*), *GS1 US* (former *Uniform Code Council*) and industry partners (Machemer 2004, 27). The institution's goal was the standardization of the RFID system's components to enable its potential for logistic and retail processes by connecting the "world of data" with the "world of things" (Clasen 2007; Weinländer 2006). Approved by *ISO*, the standard was accepted globally reducing the need for *Auto-ID's* as well as for *ISO's* own standards (O'Connor 2006; Roberti 2005).

This action started a wide distribution, and, hence, the success of the RFID technology. As a consequence, the price of standardized tags decreased from $0.50 in 2003 to USD 0.15 in 2006 (Computerwoche (Ed.) 2006; Machemer 2004, 29). Today, a tag is, depending on its function and the volume, purchasable for USD 0.05 (Ashton 2011), which was seen as the "magical" barrier for further applications. Producing companies already consider tags with a price of USD 0.01 as possible by using new manufacturing methods like inkjet printing. (Nano Dimensions (Ed.) 2015)

The Electronic Product Code, as one standardization result, gives each product an own identity. Enabling a simultaneous usage with current identification methods, the EAN or UCC code (Glover, Bhatt 2006, 27), which is used for barcodes, was utilized as a base (Machemer 2004, 29). Consisting of five parts, the *EPC-manager* (third part), a company-dependent number, and the *object class* (fourth part), describing the kind of product, represent the *EAN* code. Besides, the first part, the data head, confirms the tag as EPC tag, and the second part, the filter, is able to identify certain types of tags during a bunch reading procedure. The finalizing part of the EPC, the *serial number*, creates the uniqueness of an object (ibid.).

Besides, *EPCglobal* distinguishes different kinds of tags concerning their powering and functions. Tags, depending on their class, can be either readable, write-once or rewriteable. Their powering solution, which is a part of the air interface between the reader and the tag, can be either passive, semi-passive or active. (Glover, Bhatt 2006, 58) Whereas active tags use their own battery for communication as well as the functions of the microchip and the memories (ibid., 60), passive tags need to use *energy harvesting* due to a non-existing battery (Andelfinger, Hänisch 2015, 20). This principle receives power for communication and other functions by the modulation of reader's electromagnetic field (ibid.) initiated by certain reader-tag coupling methods (Glover, Bhatt 2006, 64–66). One common method for passive tags is the *backscatter coupling*, which leads to a reflection of the sent reader signal from the tag. Still bouncing off the same frequency, but changing certain qualities of the signal, the tag is able to send information. Furthermore, the energy of the electromagnetic field is used for the microchip, which changes the position of the resistor in the antenna resulting in an amplitude change, enabling the transfer of an encoded identification code. (ibid., 64–65) This coupling method is also used for standardized EPC Class 1

Gen II tags (ibid., 73), which are passive, readable and rewriteable tags (Weinländer 2006). Semi-passive tags are a mixture of both active and passive tags, using the battery for the functions of the microchip, and the energy harvesting principle for the communication (Glover, Bhatt 2006, 58).

Another part of the *air interface* is the *operation frequency*, which affects in combination with the power source and the tag's data encoding type the readable range distance of a tag (ibid.).

Table one, therefore, shows different radio frequencies which are useable for RFID, their typical frequency and maximum reading ranges. EPC Class 1 Gen II tags are operating, likewise ISO 18000-6C tags (O'Connor 2006), in an ultra-high frequency range from 860 to 960 MHz (Computerwoche (Ed.) 2006), of which the frequencies 902 to 928 MHz are used for the RFID tags in the Unites States and the frequencies 865 to 868 MHz in Europe (Weinländer 2006). Utilizing these frequency ranges, readers are able to read tags in a maximum distance of approximately nine metres.

Table 1. Frequency Overview of RFID
(adapted: (Glover, Bhatt 2006, 59–60; GS1 Schweiz (Ed.) N.d.)

Name	Frequency Range	Typical Maximum Reading Range
Low Frequency (LF)	30–300 kHz	~ 0.05 metres
High Frequency (HF)	3–30 MHz	~ 3 metres
Ultra-High Frequency (UHF)	300 MHz–2.5 GHz	~ 9 metres
Microwave	> 2.5 GHz	~ 10 metres

Whereas the air interface ensures the technical functionality of communication between the reader and the tag, it is the protocol determining how a message is transferred (Glover, Bhatt 2006, 77). Hence, *EPCglobal* has standardized a protocol, which is called EPC Generation II protocol (also ISO 18000-6C) (Roberti 2005). It consists of an *anti-collision algorithm*, increasing, among other improved functions, the reading speed for a bunch of tags, compared to other and the former EPC generation interfaces (Sarma 2008, 17). Able to receive and read this protocol, the reader is built up of an antenna and a controller. It is moreover connected via a network interface such as *Ethernet*, to the *RFID middleware* (Glover, Bhatt 2006, 108–109), with which the

tag data is filtered and applications are run (ibid., 139). A reader protocol ensures the communication to the middleware (ibid., 119).

Building on the reader, its software and the middleware, *EPCglobal* has created the *EPCglobal* network. Offering additional central services, it enables the transfer and access of data within and between companies with the usage of *EPC Information Services* (EPCIS) and the *Object Name Service* (ONS). Pictured in figure 3, the EPCIS collect the data from internal data bases to roll them out. The information can be received by the ONS. Similar to calling up of a webpage, the EPC-coded product information is made accessible via the product's IP address. (Clasen 2007)

Having its breakthrough in logistic processes, like the observation of a product's value chain or the tracking of shipments; the technology can be moreover implemented in many other usage areas: In the health care sector, as one example, hospital equipment can be equipped with RFID tags making its location possible, which is necessary for efficient processes (Mojix (Ed.) 2015) (Yao et al. 2010). In libraries, books are equipped with RFID tags eliminating the need for scanning each book during the borrowing process due to the usage of shelf-integrated readers (Lampe et al. 2005, 72). It also can prevent theft in the apparel stores (Tellkamp, Quiede 2005, 147). In sports, RFID enables further applications. Whereas it is already used for time measurement, a new application combines the existing technology with marketing. The agency, *Revolution Sports Marketing*, provides the opportunity to add personal messages or campaigns to the RFID tag of a certain marathon runner, which is shown on screens by the athlete passing the reader, leading to a motivational effect. (PR RFID (Ed.) 2017)

Besides, RFID is able to extend its field of application being combined with WSN. Combining a sensor and a tag, or integrating the sensor directly into the microchip enable, for example, the sensing of temperature or humidity. This can be useful in an exemplary supply chain application, in which the temperature of a product has to be observed during its transport from the production to the point of sales. In addition, gas and shock detecting sensors can be combined with the RFID technology. (McEwen, Cassimally 2014, 238–240; Mersch 2017) While this system is already commonly used, experiments for replacing it in the future are ongoing. Researchers of the technical university in Freiburg are currently developing materials, which have a

micro structure based on rare earth metals. These structures are able to replace and control production processes by changing the material's physical characteristics. Experts have the vision that those *smart materials* could enable an autonomous communication to machines as well as having directly integrated sensing functions. Nonetheless, until this technology becomes mature, objects and materials with attached RFID tags including optional sensors are seen as the preferred technology. (Mersch 2017)

Next to RFID, the *Near Field Communication* (NFC) is used for IoT purposes. Based on short-range RFID tags, it combines the receiving function of a reader as well as the sending capability of a tag. This is based on the *NFC Data Exchange Format* (NDEF), which enables a communication into both directions, leading to a bidirectional transfer of data between devices and tags. (Rowland et al. 2015, 44–45)

2.3   Effects of IoT and RFID on the Retail Industry

Both the NFC and the RFID technology show their significance for IoT solutions, among others, in the retail industry. Whereas the Near Field Communication is commonly used for smartphone or wearable payment, e.g., *Apple Pay* (Apple Inc. (Ed.) 2017); RFID facilitates logistic processes and takes part in enhancing the customer experience. Research institutes, like *Juniper Research*, and leading managers of the RFID producer *Avery Dennison* and the sports article manufacturer *Adidas Group*, therefore; designate it even as "the industry's great" or "key enabler".

This perspective results, in especially, from RFID's impact on the so-called *omnichannel* in the apparel and footwear sector (Deans 2017; Zaczkiewicz 2017), which requires efficient logistic processes to enable a well-functioning shopping experience. This kind of sale strategy has the intention to "… integrate different methods of shopping …" (Oxford University Press (Ed.) N.d.b) by "…providing a seamless shopping experience in brick-and-mortar stores and through a variety of digital channels…" (Sopadjieva et al. 2017). Based on a study of 46,000 American shop customers, 73% take advantage of shopping via different channels. According to *Capgemeni's* consumer good & retail manager (Plewinski 2017), not only fulfilling the customer's wish of flexible and comfortable shopping, but also enabling a seamless channel experience helping the retail companies to increase the sales per purchase. It doesn't only rise in

average by 4-9% for in-store and by 10% for online purchases, but, moreover, increases, the purchase frequency due to an increased customer loyalty. (Sopadjieva et al. 2017)

Nevertheless, *PriceWaterhouseCoopers and JDA Software* noticed in their survey "CEO Viewpoint 2017: The Transformation of Retail" with more than 300 surveyed managers of global companies that their investment to improve the shopping experience, yet, doesn't fulfil the customers' shopping channel preferences. Only 10% of the surveyed, exemplary German managers are able to offer a seamless experience, whereas other 47% see omnichannel as too expensive and difficult to implement. In addition, the sales strategy's profitability creates a challenge. (JDA Software Group Inc., PwC (Eds.) 2017, 1, 6-7)

A first step to an efficient omnichannel strategy is, according to the key account director of the merchandise protection solutions *Checkpoint Systems*, the implementation of *click & collect* allowing the customer to receive the online purchased products in the physical store (van Bocxlaer 2016). It can be exemplary realized by attaching RFID tags to clothes and shoes, to thereby profit from RFID's identifying and locating capabilities. Using specialized middleware applications, the products' data can be likewise Kevin Ashton's IoT solution at *Proctor & Gamble* made visible in the company's ERP system or in the web (Deans 2017; Donaldson 2016).

Regarding the consultancy *Kurt Salmon* and its 2016 study "RFID in Retail", which was conducted with 60 retail and wholesale companies having at least 500 million US dollars in sales, the implementation of RFID enables an increase of the inventory accuracy from 67.4% to 84.5% (Unger, Sain 2016, 2–3). Additionally, leading to a better overview of products on stock for the store administration and their refill in case of an out-of-stock event by the staff, customers are able to find products easier and faster. As a consequence, the in-store shopping experience can be approached, of which 66% of certain German customers think it is deteriorated by not finding the right product (Plewinski 2017). Thus, the customer satisfaction can be increased from 64.6% to 71.7%. (Unger, Sain 2016, 3)

Furthermore, the improved shopping experience is able to activate a sales increase of 5–25%, contrasted to an average sales loss of 8.7% based on the low inventory

accuracy of a brick-and-mortar store without RFID. Also, a higher profit margin (from 8.9% to 14.3%) and a reduced need for markdowns (from 14.8% to 11.9%) can be achieved. (ibid.) The *Platt Retail Institute*, which conducted a research about the RFID implementation at *Macy's*, confirms this tendency in certifying a reduction of out-of-stock situations from 30% to 4–6%, and a reduction of markdowns in the sector of Women's shoes by 2.6%. Furthermore, the inventory variance was reduced from 4–5% to 2–4.5%. Even though the omnichannel order fulfilment could be increased by 6.1%, the research didn't offer any content about the changes in the inventory accuracy. (Lines 2017) (McKevitt 2017)

Next to RFID, other solutions can enhance the customer experience via the omnichannel. One example are *Bluetooth beacons*, which connect the customer in the physical store with the web shop via a beacon-based app, or provide the customer with personalized information, like discounts or special offers (Swedberg 2017). Also, interactive shelves keep customers informed by emitting additional information to a digital signage after a certain product has been touched or moved (Impinj (Ed.) N.d.). Another example is an interactive mirror, which can be, e.g., connected to the web shop. 47% of shopping customers, surveyed for the 2017 study "Future of Retail: Insight and Influences Shaping Retail Innovation" of *Synchrony Financial*, see these mirrors as "… one of the three most exciting innovations of the future". (Slaven 2017) According to "CEO Viewpoint 2017"-study, these IoT solutions next to big data, robotics and augmented reality, are technologies leading retail companies are investing in (JDA Software Group Inc., PwC (Eds.) 2017, 3). Due to IoT's expected increase of global retail sales by 1.2 billion US dollars (Oberschür 2017), an amount of 12.5 billion things and smart devices, like beacons, are forecasted to be connected to IoT middleware platforms by 2021 in the retail industry. Compared to 2016, an increase by 350% may be reached. (Swedberg 2017)

2.4 Usage of IoT

Not only in the retail industry, has IoT shown its impact. Based on a study by the research company *Gartner*, 8.4 billion things will be connected to the Internet in 2017. The forecasted amount for the year 2020 varies between 20.4 billion (van der Meulen 2017) and 50 billion (Ericsson (Ed.) 2010). This wide distribution is, among others,

based on the falling price of connectable IoT hardware, which the consulting company *McKinsey* expects to decrease from an average price of four euro to two euro until the year 2020. (Bucher 2017)

Coming into operation in different fields of application, consumer and industrial IoT applications have to be discerned in the first instance. Industrial applications, or IIoT, had a stake of 60% in the total amount of connected things in the year 2015, based on a prediction of the audit and consulting company *Deloitte* (Lee, Stewart 2015). According to *Oxford Economics*, industry sector applications contribute 62% to the GDP of the G20 states (Daugherty et al. 2015, 4). Litzel (2016) describes the goal of IIoT applications as the ambition to make processes, e.g., in the production, more efficient and cheaper owing to their automation, which is based on a direct communication between machines, systems, parts, products and users. This is the reason, why companies in Germany, as a representative country, commonly use IoT for a connected production, connected products, logistics and a smart supply chain (Schirge 2017). The outcome of the *IDG Business Media's* study "Internet of Things in Deutschland 2016" also shows other upcoming IoT projects in facility management, connected health, connected cars and smart home (ibid.). Due to this intruding of IoT in many new areas, which include: developing, producing and advising companies; the amount of IoT solutions is growing. The "IoT clusters study" by the *Join Institute for Innovation Policy* (*JIIP*) and the auditing company *KPMG* shows an increase of European IoT companies from 180 in the year 2005 to more than 1000 in 2017. Next to business solution development and advisory, these firms are focused on IoT platforms as well as smart home and smart energy applications. (Dümichen, Sternberg 2017)

Companies of the latter field of focus do not only provide B2B solutions, like controllable office building lights (Harvard Technology (Ed.) 2017), but also products for private homes. These have the goal of making day-to-day interactions more comfortable and efficient (Litzel 2016). An exemplary consumer application is the *Philips' Hue* system (see figure 5), which allows users to control the brightness or the light colour through a mobile app or a wireless switch (Rowland et al. 2015, 10–11). Other smart home companies such as *Nest* or *Tado* (ibid., 35) offer intelligent thermostats (see

figure 5), which are controllable through an app as well as through direct interaction (ibid., 6).

Figure 5. Philips Hue with app, hub and bulbs (Personal wireless lightning 2016) and a Nest Learning thermostat with app (Nest Thermostats 2016)

These exemplary applications show the importance of mobile phone or tablets for IoT. That is why Andelfinger and Hänisch (2015, 62) claim that mobile devices are predicted to have the role of a "digital assistant" providing the central user and access interface for more consumer IoT solutions in the future. Being a competitor to the smartphone, another IoT device is able to function as a central interface. There are, e.g., *Amazon's Echo* with its voice service *Alexa,* or *Google's Home* with the *Google Assistant*, which are intelligent speakers being able to control different kinds of smart home devices like the *Philips Hue* bulbs, intelligent thermostats, or answer questions according to the user's voice. (Weddeling 2017)
Next to the smart home and smart energy solutions, there are huge numbers of other consumer IoT solutions, e.g., smart gardens, which measure the concentration of nutrients and show the results on a mobile app, or sensors which are integrated into running shoes measuring metrics such as speed and distance. (Andelfinger, Hänisch 2015, 39)

During their usage, both industrial and consumer IoT solutions create and collect a big amount of data, which will likewise the things increase. In this context, a study of the hardware producer *EMC* and the research company *International Data Corporation* (*IDC*) claims that the data of IoT systems contributed two per cent to the data of the comprehensive, so-called *digital universe* in the year 2013, and is forecasted to increase to 10% of an overall data amount of 44 zettabytes, or 44 trillion gigabytes respectively, until 2020. (EMC 2014) This IoT systems' data consists of different types of information. On the one hand, things generate data, for instance, about their environment, like the temperature, its location or its status. On the other hand, things can collect data about their users, for examples, their condition, their movements or

actions. (Rowland et al. 2015, 538–539) The data can be consequently either used directly to enable functions and actions by processing it, or to open new business field of big data (Bucher 2017). Whereas analysing the big data can help the company to make processes more efficiently as well as creating a foundation for future decisions and actions alternatives (ibid.), providing filtered data packages to third parties, which can be utilized for purposes like personalized marketing, is an additional profitable business for the data provider (Pfannenmüller 2017).

Due to collection, transportation and access of data, the IoT system's security and privacy has to be considered for their usage. Rowland and colleagues (2015, 420) describe security as "… the degree to which a system can protect the assets it contains from unauthorized access, modification, or destruction." They furthermore refer to the tree main, so-called *CIA* aspects *confidentiality*, which defends unauthorized access, *integrity*, which protects the information from unauthorized manipulation and elimination, as well as *availability* which prevents the loss of data due to a purposely destructed system. The authors (ibid., 420–422) additionally claim that a system can't be totally secure, and, therefore, suggest next to encryption, authentication for usage access as the "… most important defence mechanism…" to increase the security. In addition, Litzel (2016) likewise highlights the importance of authentication management to access a system and encryption. Brandner (2017) appends to both opinions that it is not enough to just have an authentication system, but also to update it regarding the risk of predefined passwords. He sees it easy for hackers to ascertain them and, consequently, access the systems unauthorizedly.

Additional solutions for increasing the security can be the installation of system firewalls, an update management for eliminating identified security flaws (Litzel 2016) or a software for companies to identify attacks by anomaly events in the network traffic (Klapdor 2017).

Regarding the study "2017 Study on Mobile and IoT Application Security" by *Arxan Technologies* and *IBM*, which was conducted by the *Ponemon Institute* with 593 IT security representatives of users (Ponemon Institute *et al.* (Eds.) 2017, 2), developers and manufacturers of IoT devices; 58% of the participant are worrying about being hacked through an IoT app (ibid., 3). Even though the organisations are aware of the

risk coming from IoT systems, 48% of companies do not test their solutions for security issues at all (ibid., 12). Based on a survey of the telecommunication company *AT&T*, just 10% of 4250 questioned IoT development companies are even sure that their systems are able to defend hacker attacks (Weddeling 2017) Next to an authorized access, for example in companies' Internet networks (Alkassar 2016) and its manipulation or elimination of data in the Internet; hackers are able to create further damage through the unauthorized access of IoT systems. Rowland and colleagues (2015, 426) mention the example of a baby phone which was illegally accessed to abuse a child verbally. In addition, they emphasize the potential of endangering people's life by remote-controlling connected cars and peacemakers.

If a system was however hacked, also private and sensitive data is often accessed unauthorizedly and stolen. But also during the normal usage of connected devices, this kind of data can be either collected purposely, e.g., for CCTV footages, or unintendedly, collected, accessed and used by taking pictures randomly (McEwen, Cassimally 2014, 31). This is why legal issues have to be considered while creating IoT solutions (Rowland et al. 2015, 445). *Panasonic*, as an example, improved the privacy consideration of its security cameras by blacking out areas or masking people, of which the information either isn't necessary or too sensitive for observing security companies. If, however, the details behind the blacked out areas or masked people become necessary, e.g., in case of theft, it can be accessed after authorization. (Panasonic Business (Ed.) 2016)

2.5   IoT Development Requirements and Challenges

Due to the risk which comes with the collection and usage of data, experts claim that both data security and privacy have to be already considered during the development of IoT systems (Alkassar 2016; Rowland et al. 2015, 448). Regarding the study of *Arxan* and *IBM* in this context (see chapter 2.4), 70% of the participants say that their budget is insufficient for protecting apps and IoT devices (Ponemon Institute *et al.* (Eds.) 2017, 9). Also, the rush for releasing software is mentioned as a reason for the existence of security flaws (ibid., 14). These can be eliminated with updates in retrospect, or during development with *security by design* and p*rivacy by design*. The latter procedure was created as global standard by the *International Conference of*

Data Protection and Privacy Commissioners (Rowland et al. 2015, 449) and makes arrangements such as the usage of the lowest possible amount of personal data and an encrypted transport of sensitive data, which both have to be considered and implemented already during the development (Schaar 2010). The same applies to security by design, with which security concepts are proactively integrated into the system to reduce the risk of attacks (Alkassar 2016).

Before both design procedures can be applied, it is important to know, what kind of information the IoT system collects, to whom it belongs (McEwen, Cassimally 2014, 31) and who should be able to access it. Rowland and others (2015, 209) call this procedure *designing with data.* It should lead to an overview of interrelations and reactions. Not only has the cyber security of IoT systems to be considered, but as well the illegal physical access of IoT devices (ibid., 431). A small design detail which could make them unattractive to be stolen, shows that IoT systems are not exclusively about data, software and the Internet. They are however substantial components.

Regarding IoT's architecture (see chapter 2.2), the involvement of many different disciplines such as software, electronics, product design, functional design, and service design can be derived for the development of IoT solutions (McEwen, Cassimally 2014, 147; Rowland et al. 2015, 594). This makes the products consequently more complex and leads to additional requirements groups for their development (McEwen, Cassimally 2014, 38). Next to the hardware perspective, which demands a simultaneous good appearance and usefulness as well as the requirement of being easily producible (Rowland et al. 2015, 256–257); software poses several challenges besides data security and privacy. Due to the Internet being build up on a big number of open standards, the right ones for the solution have to be identified (ibid., 411). For this purpose, characteristics, like the communication range of the network, the information request frequency of the application and the energy consumption of the data transmission have to be considered. Due to the interdependencies between those three characteristics and the commonly limited energy capacity of IoT devices, the right performance balance has to be found not to compromise the device's lifetime. (McEwen, Cassimally 2014, 214–215) Also, the importance of the intellectual property has to be conceived for the choice of open or closed source codes. Whereas closed source codes protect the property of the solution, which is an advantage

towards competitors, open ones offer the codes to a third party without the need for a license. Admittedly, the solutions can be more easily imitated, but it enables an easy creation of complimentary products without the need for purchasing expensive licenses. This encourages interoperability. (ibid., 77–83) For interoperations between things and the web service, the communication, based on differing standards, can be ensured using gateways. Problems due to differing standards can still occur, e.g., while integrating things in IoT solutions of other manufacturers (Rowland et al. 2015, 411). If the source code, however, is open or licensed, several solutions can build around the original one leading to an additional value (McEwen, Cassimally 2014, 81).

This interoperability, moreover, has to be ensured by the fitting IoT platform, on which the web applications can be developed. As middleware between the Internet transportation layer and the application layer, it has to support these differing communication languages being able to utilize the incoming data through provided APIs for the programmed applications. Therefore, the right platform has to be chosen considering its support of the necessary standards. (Pérez, Bernardos Barbolla 2014, 19) Schirge (2017) dedicates the criterion of provider know-how as the most important one for the platform choice. It is reasoned by the platform's role as a base for all applications and its consequent responsibility for offering a good and secure service.

Enabling the functions of the software and IoT platform, also considering the collaboration with the hardware, an electronics platform is required (McEwen, Cassimally 2014, 96). Regarding the example of a parking IoT application, which should detect empty lots making them visible through a web app, the appearance of the hardware is due to its invisibility for the user neglectable. Nonetheless, the right sensors and electronic platform for the sink node have to be found enabling the detection of a car on a parking lot as well as sending the resulting information to the database. (Delicato et al. 2013, 61–62) In contrast to software development, which can be performed iteratively without leading to a final source code, hardware and electronics still have the difficulty of requiring a *design freeze* for the production. Including mistakes which compromise, e.g., the functionality or security leading to a necessary change (Rowland et al. 2015, 316), software is able to fix them by emitting updates.

Physical products, in comparison, can't be changed after leaving the production without requiring, e.g., expensive recalls (ibid., 238–239).

Preventing additional expenses or unsatisfied customers, the development of an IoT product can't just exclusively be considered from a software and a hardware perspective. The demand for a holistic view (ibid., 255) is increased due to interactions of IoT products with a user or another system as well as its integration into a system. McEwen and Cassimally (2014, 23), additionally, emphasize that appreciated solutions can't be just created with technical solutions only. They, however, have to be integrated into a conceptual model, as they define the functions of a system (ibid., 26). This starts with the functional design, also called *interaction design* (Rowland et al. 2015, 22), defining how software and hardware are aligned to create a system which is understandable for its users (ibid.). Even though IoT solutions have the intention to solve a user's need or problem (ibid., 128), their usage often causes difficulties due to the increased complexity, compared either to systems in organizations or to day-to-day products which aren't connected to the Internet (ibid., 114). Rowland and colleagues (2015, 208) claim that this additional component often leads to behavioural changes in the usage, wherefore developers have to, at first, conceive how users and systems behave while performing these interactions with an IoT solutions. Therefore, they have to be divided into different kinds of user roles. Whereas *actors* are actively involved filled by people, e.g., touching a touchscreen; *stakeholders* are just interested in the functionality and the outcome of their usage. This role type could be applied to an organization, which is creating usage training plans or processes the data being created by the actors. (ibid., 154)

This holistic perspective will consequently lead to new insights, e.g., in the form of a usage flow (ibid., 22), which could trigger necessary changes to the developed concept. Possibly effecting how source codes have to be written or what kind of technical requirements the hardware has to deliver, the product or web interface have to be also considered from the industrial or product design perspective (McEwen, Cassimally 2014, 22). This results, for instance, in shapes or a certain layout of components and materials which need to be adapted to the interaction with users and systems. (ibid., 23)

Regarding the example of an intelligent thermostat, a direct control through an interface on the thermostat wouldn't be required for the user who can control it through the web interface. Admittedly, it causes extra costs and increases the energy consumption, but becomes, nonetheless, necessary, e.g., in case of an Internet connection failure (Rowland et al. 2015, 9, 313-315) In contrast to products without Internet connection, IoT solutions often carry a service as part of their system (McEwen, Cassimally 2014, 22). These services can be, for instance, complimentary web applications or software updates (Rowland et al. 2015, 518). Enabling a coherent solution over the complete product lifecycle, the development has to be extended to service design as well (ibid., 24).

Next to the summarizing the four requirement groups of the IoT product development: hardware, software, electronics and service; following challenges can be identified:

- an **increased number** of involved **disciplines**
- an **increased occurrence** of **interdependencies** between the **disciplines**
- a resultantly **increased complexity**
- a **development focused** on the involved **users** or **systems**

Being able to handle these challenges, Rowland and colleagues (2015, 3) as well as Song and others (2014, 76–77), moreover, highlight the necessity for an extension of the development team being able to address additional fields like service or functional design resulting in the development of a, by Rowland and colleagues (2015, 3) described, "…useful, usable, and pleasurable…" Iot product. McEwen and Cassimally (2014, 284) confirm Rowland and others' as well as Song and colleagues' opinion, but underlines the additional challenge of transforming a well-functioning prototype to a serial product owing to the difficulties of a hardware design freeze (Rowland et al. 2015, 316), changing user needs (Andelfinger, Hänisch 2015, 67) or testing the product holistically in its future environment (Baumgartner, Mlynarski 2017).

Although experts, like Rowland and colleagues (2015), Baumgartner and Mlynarski (2017) as well as McEwen and Cassimally (2014) provide approaches to facilitate certain parts of the development of IoT solutions, like IoT testing approaches (Baumgartner, Mlynarski 2017) or the support of video prototypes (Rowland et al. 2015, 588); a comprehensive basic approach being able to handle the identified challenges,

isn't described. A framework for IoT development projects, however, becomes necessary being able to handle the requirements and challenges occurring in the IoT product development.

3   Agile Project Management (APM)

Project management, which plans, organizes, leads and controls IoT development projects (Patzak, Rattay 2008, 24) could be able to provide the required framework. Without a fitting structure, efficient processes and the right tools, the requirements and challenges of the IoT development can only be hardly met.

As illustrated in the following chapters, *agile project management* was originally created to handle fast changing environments of software developments (Cockburn 2006, 367). Nonetheless, it is applied to other kinds of products, as an approach being able to handle their complexity as well as putting the user in the centre. That is why chosen agile project management approaches are going to be described and analysed, proving a possible contribution to Internet of Things development projects.

3.1   Basics of Agile Project Management

Before specifying different approaches, it is important to understand the breadth of agile project management.

3.1.1   Term Definition Agile

As will be seen in the next chapter, APM's underlying values and principles are based on the sense of the term *agile*. It originates form the Latin word "agilis" standing for quick and easy movements (Oxford University Press (Ed.) N.d.c). From a zoological perspective, it is therefore associated with animals such as tigers or leopards owing to their nimble movements. In a sports environment, e.g., football, agile players are able to move fast and easily (Cambridge Academic Content Dictionary (Ed.) N.d.).

Next to the general definition, there is also one for agility in the business context. The *Business Dictionary* defines it as "the capability of a company to rapidly change or adapt in response to changes in the market" (Business Dictionary (Ed.) N.d.). James Highsmith, one of the founders of agile project management, describes it in a similar way. He sees it as "the ability to both create and respond the change in order to profit in a turbulent business environment", as well as the ability to handle flexibility and balance. (Highsmith 2002, xxiii) Alistair Cockburn, another foundation mem-

ber of agile project management prefers the definition of Steven Goldman " (Goldman et al. 1995, 42) published in his book: "Agile Competitors and Virtual Organizations. He characterizes agility as "… dynamic, context-specific, aggressively change-embracing, and growth-oriented". (Cockburn 2006, xxvi)

Even though those definitions originate from different environments and different perspectives, similarities are visible. All have in common that agility is connected to speed and the ability to move or react to a certain changing condition fast and easily. In the business perspective, agility is, furthermore, a characteristic being able to grow and to subsequently gain profit in a changing environment.

3.1.2 Agile Project Management and Agile Manifesto

To, hence, understand, how the characteristics of agility are implemented into project management, APM's origin has to be regarded in more detail. A first idea of the former *light* or *lightweight* approach for project management was published in 1970 by Winston Royce. In his paper "The Development of Large Software Systems", he mentioned the idea for an approach handling the development of large software systems. (Winston W. Royce 1970) Continuing from the 1990s, several approaches for changing the way of developing software, like the *Dynamic System Development Solution* (specified in chapter 3.2.2), appeared. This movement peaked in the year 2001. (Blankenship et al. 2011, 5) During the year, 17 representatives of different, still called, light development approaches assembled, and formed the *Agile Alliance*. The discussion's goal was not to create one common process, but to find similarities between their approaches. (Cockburn 2006, 367–369)

Their first result, also described as first level of results, was the term change from *lightweight* to *agile* as foundation for their approaches. They reasoned it with its positive emphasis for their most important common value: *respond to change*. The adjective lightweight, in contrast, would negatively decline a certain characteristic. The second level of their outcome was the development of four values describing a detailed sense behind agile and their goal to develop software in a more efficient way (ibid., 367):

- "**Individuals and interactions** over processes and tools"
- "**Working** *software* over comprehensive documentation"

- "**Customer collaboration** over contract negotiation"
- "**Responding to change** over following a plan"

Furthermore, they created twelve statements breaking the values down into a more detailed third level. All of their results were consolidated and integrated into the so-called *Agile Manifesto*. (ibid., 370)

Today, the Agile Manifesto is still valid as the usage foundation for the available, and the creation of new approaches. Since 2010, also complementary agile standards and official certifications, for example, from the *Project Management Institute*, are offered. (Preußig 2015, 7)

3.1.3 Demarcation of Agile Project Management

The original goal of agile was the improvement of software development projects (Blankenship et al. 2011, 5). Today, however, it is possible to use some of the approaches as well for all kinds of non-software development projects (Preußig 2015, 7). Confirmed by Cockburn (2006, 222), agile methods can be used for several circumstances. For him it is not about which method of APM is the best, but how it has to be used to become agile.

Subsequently, APM has to be demarcated regarding different definitions and descriptions not to lose focus. Whereas different project management organizations subsume the raw movement as agile project management, wherefore they offer related certifications (Preußig 2015, 7), there are also more detailed specifications. Gernert (2003, 5) summarizes APM as a collection of ideas and practices which are situation-adapted and demand-based leading to agility encouraging customer satisfaction, motivating teams and managing risks effectively.

According to Highsmith (2002, xxiv) APM, in consideration of the software development, doesn't only consist of ideas and practices, but should be seen as a whole environment. Specifying in his later book (Highsmith 2010, 20), he describes the APM for different kinds of projects with an ecosystem's compromising items: opportunities for the development, agility's values and principles, as well as practices implementing agility in projects and organizations. This specification goes hand in hand with Boehm and Turner (2004, 45) who additionally break down APM. They, in contrast,

divide it into technical methods and tools, communication tools and management tools. As can be seen among the different definitions, there isn't a certain one defining and demarcating APM in a standardized way. Summarizing it from a content-related perspective, APM focuses on the implementation of the agile values and principles, like the communication between the stakeholders, but also on the risk management to reach the main goal of a satisfied customer. This goal is achieved with the support of methods and tools. Furthermore, a structural pattern can be perceived while analysing the definitions. Whereas all of them describe tools either directly or represented by the general approaches from an intra-project perspective considering different methods and tools, Boehm and Turner also mention additional managing tools. In addition, Highsmith goes the extra mile in additionally describing APM in a superordinate level. He addresses the necessity of agility in the organizational structure.

As a result, an APM structure can be defined, which shows the possible application of the agile value to subdivided levels. As plotted in figure 6, the basic level is represented by the intra-project or development level, followed by the project level concerning the managing and leading of projects. The highest level is the organisational level, which considers cross-company structures.

Figure 6. Agile project management structure

3.1.4   Agile Project Management Framework

After the demarcation of APM, it is the next step to gain knowledge about the content of each level. Before regarding different agile solutions (see chapter 3.2), it is necessary to define a certain structure for their content analysation. Highsmith (2002, xxiv), as an example, uses the overviewing term *ecosystem* for the content description consisting of agility's values and principles, as well as practices implementing agility in the project and management level of APM. Contrasting his definition with the classical content structure of projects (Pfetzing, Rohde 2009d, 31), reveals

the lack of roles within a project. Taking the different agile approaches, like Kanban, into account, the term *process model* (Epping 2011, 17) is commonly used giving an overview about their content. Understanding the context, Versteegen (2000, 23) describes a process model as "… a description of a coordinated approach for the implementation of a project. It defines the input which is necessary for the implementation of activities, as well as the output produced as result of the activities."

While comparing the different content structuring descriptions, several common characteristics can be identified:

- **Values** and **principles**
- **Roles**
- **Practices**
- **Process**

Nonetheless, they aren't contained within one certain approach. Thus, subsuming them within the term *framework*, enables the opportunity of analysing the different agile approaches in a structured manner. Consequently, this overviewing and general phrase is able to consider the levels' content based on agile values and principles as well as the roles, agile practices and their process.

3.2   Illustration of Chosen Agile Project Management Approaches

Today, several agile approaches are available. These are, for instance, the ones being based on the agile values of the Agile Manifesto: *Adaptive Software Development*, *eXtreme Programming*, *Scrum*, *Crystal*, *Feature-driven Development*, *Dynamic Systems Development Method* and *pragmatic programming* (Cockburn 2006, 369). Most of them, however, are mainly geared to improve development projects for software. Nonetheless, Scrum and the Dynamic Systems Development Method (DSDM) can be also applied to non-software products. (Craddock et al. 2014, Abstract; DSDM Consortium 2008, Abstract; Preußig 2015, 7) This quality becomes essential being able to develop and integrate the hardware, electronics and service components into IoT product innovations. Furthermore, it is also Scrum's popularity (Rubin 2012, vii), wherefore this approach was chosen to be analysed. DSDM was selected due to its consistence of best practices (Craddock et al. 2014, 2.6) as well as its coverage of the

whole development project lifecycle (ibid., Abstract), which, as will be shown in chapter 3.2.2, makes up a difference to Scrum.

The third approach being analysed is *Kanban*. In contrast to the other two approaches, it is characterised as not completely agile. As chapter 3.2.3 specifies, Kanban is due to its origin, in fact, a project management approach being based on agile and *lean* values.

The three approach descriptions contain several similar methods. That is why they will be explained in detail during their first occurrence, and just mentioned in their following appearances. Nevertheless, differences will be highlighted.

3.2.1   Scrum

Starting the illustration with Scrum, leads to a first detailed specification of an agile approach. Its name originally comes from a crowding move in the sports, rugby, where players try to get the ball and bring it to the goal as a team. (Rubin 2012, 35–36) Its first idea, however, goes back to the year 1986 during which an article describing certain principles of today's approach was published in the *Harvard Business Review*. Seven years later, Jeff Sutherland as part of a software development team extended the basic idea to make it usable for software developing processes. Hereafter, Ken Schwaber, also a software developer, and he improved the method steadily, and published it in several books. (ibid., 3)

Values and Principles

Playing, or in a business environment working in a self-organised team is one of the 12 agile principles. They, therefore, provide in addition to the four values of the Agile Manifesto the base for the Scrum approach. Besides self-organised teams, other important principles are the simplicity of work and tasks, an iterative process, as well as welcome changes. (Preußig 2015, 47) Rubin (2012, 31) additionally highlights among others, variability and uncertainty as a helpful characteristics. Through the iterative process of agile approaches, a learning and feedback effect can be generated which is implementable in further iterations to adapt the solution to the new knowledge and changed conditions. In Scrum, those characteristics are absorbed by a value triangle with fixed time and resource constraints and a variable content scope being able to react on feedback and change requests (Blankenship et al. 2011, 16). Due to

its base, the approach is not only seen as a process model or framework, but also as a philosophy (Hruschka et al. 2009b, 70).

Roles:
Usage of
Pronoun "he"

Actively involved in the approach, the Scrum team consists of three roles. The overall success of the development process is up to the **Product Owner**. Illustrated in figure 7, he contributes the product vision to the process, while representing the customer's interests. (Blankenship et al. 2011, 22) To prevent conflicting ideas and product requirements, the Product Owner is always filled with only one person. This facilitates the collaboration with the customer concerning product requirement prioritisations or changes as well with the **Scrum Master** and the **Development Team**. (Rubin 2012, 16)

In contrast to the Product Owner, the "**Scrum Master**" is exclusively responsible for the execution of the agile framework. He has the function of an agile coach guiding the involved members through the change, which the Scrum approach implementation causes. This doesn't mean that he is managerial prerogative, but he has the responsibility to handle problems or violations against the agile values, principles and process. (ibid.) Blankenship and colleagues (2011, 22) also see him as a conflict manager advocating agility and the Development Team's interests against the Product Owner. Both can be infringed, for instance, due to the Product Owner eroding the Development Team's autonomy by telling it how to develop. This represents one of the reasons, why the roles of Product Owner and Scrum Master conflict in being combined. (Preußig 2015, 141–144)
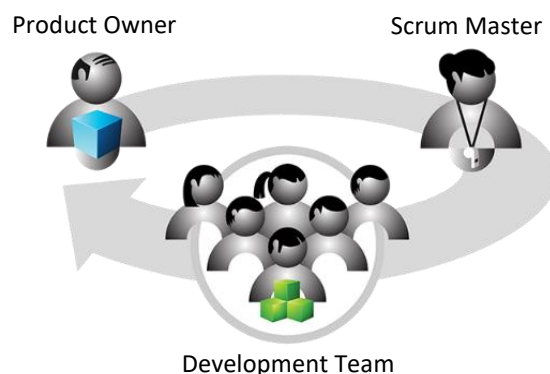
Figure 7. Scrum roles
(adapted: (Rubin 2016))

The responsibility of implementing the Product Owner's requirements and following the Scrum Master's guiding has to be carried by the Development Team. It functions

as a provider of the deliverable solution. Consequently, the team has to align different skills being able to develop software or other products. Rubin (2012, 16) describes it as a "diverse, cross functional collection of … people". Due to their self-organisation, the team members have, compared to traditional projects, a higher responsibility to deliver results (Preußig 2015, 144). The recommended amount of members varies, depending on the author, between 2–10 (Blankenship et al. 2011, 23) and 5–9 people (Rubin 2012, 16). Nonetheless, all three roles can be applied for different sizes of teams. Whereas, small teams can integrate a Product Owner into the Development Team, as well as combining the Scrum Master role with a Team role (Preußig 2015, 141), bigger teams can be split into several smaller Scrum Teams (Mundra et al. 2013, Abstract).

According to the applicable chicken and pig story in the appendix A.2, roles can be subdivided into active Scrum or pig as well as passive or chicken roles. The latter ones can be, depending on the situation, managers or stakeholders, like customers or suppliers, and additionally added (Blankenship et al. 2011, 22–23).

Practices
Before describing the Scrum's process model in detail, it is necessary to understand certain practices, in Scrum also called *artefacts* (ibid., 17). The first one has a big influence on the agility of the Scrum framework, and, moreover, is performing one of its principles. In contrast to traditional development approaches (see chapter 3.4), the products are developed in iterative cycles, so called **Sprints**. During one iteration, a certain number of requirements is developed from the idea to the finished solution. (Rubin 2012, 20) Due to this iterative principle, intermediate feedback can be generated making it possible to react faster on changes and occurring problems (Preußig 2015, 29). Those iterations are *timeboxed*, which means that they have a fixed beginning and end, as well as each of them has the same length. According to Rubin (2012, 61), the optimal duration is 1–4 weeks without a break in between subsequent Sprints (Preußig 2015, 147). This practice was created based on the *Pareto-principle*, which says that 80% of the result is usually achieved from 20% effort. Regarding this principle and time management, staying in the planned timebox with a variable content scope is more efficient than extending it. (ibid., 107)

A Sprint is terminated with the release of a so-called **Increment**. It describes a sub product of the whole solution, which builds upon former iterations (ibid., 51). Consequently, it shouldn't be seen as a prototype as it is theoretically sellable (ibid., 53). Before being able to develop sub products, a **Product Backlog** has to be created. It contains the requirements the Product Owner and a potential customer have defined. In contrast to other authors, Rubin (2012, 18) also sees an input from other stakeholders and Scrum Team members as part of the backlog creation. Due to the agility welcoming changes and its iterative idea, the backlog is never completed. (ibid., 19) That is why the Product Backlog shows several necessary requirements and possible features, which could be developed forming the entire product. Concerning the agility's iterative principle, it is too extensive, making it impossible to develop it during a single iteration. Consequently, it has to be broken down into several smaller backlogs. Those smaller ones, also called "**Sprint Backlogs**", represent the features and their detailed tasks, which can be developed and finished during one iteration. (ibid., 21)

There are several ways to convert the vision into requirements and features to fill the different backlogs. Traditional specification sheets have led to many misunderstandings due to the complexity of software. A practice within Scrum's framework tries to facilitate the creation and communication of complex requirements. **User Stories** are short product use cases written from the customer or user perspective (Preußig 2015, 92). As e*pics,* they are overviewing and used as a placeholder in the Product Backlog (see figure 8). When breaking them down to fit them into a Sprint Backlog, they can be specified into *features*, *themes* and *sprintable Stories*. (Rubin 2012, 86) These terms, though, aren't compulsory. Other authors like Patton (2014, 77-78) alternatively use *activity*, *task* and *sub-task* (ibid., 71).
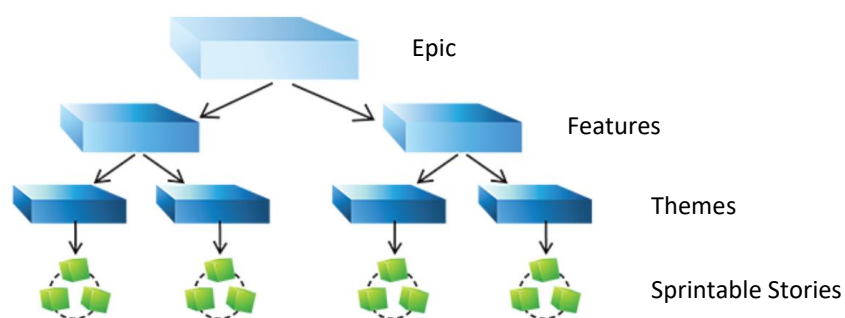
Figure 8. User Story sizes
(adapted: (Rubin 2007-2017, chapter 5))

To fulfil the principle of the user centric perspective, there are several characteristics a good User Story is supposed to have. Those characteristics are pooled in the commonly used acronym *INVEST* (Blankenship et al. 2011, 18):

- **Independent:** A story shouldn't depend from other User Stories
- **Negotiable:** A story should welcome changes
- **Valuable:** A story should focus on the customer value
- **Estimable:** A story should be able to be sized
- **Sized appropriately:** A story should have a size making it able to be planned and prioritised
- **Testable:** A Story should have related quality criteria enabling a confirmation with a test

Those characteristics lead to an improved understanding of the requirement description from the customer's, user's and developer's point of view (Preußig 2015, 92). Besides, the latter perspective is facilitated by Ron Jeffries' suggestion of using a small card illustrating it. Shown in figure 9, Mike Cohn designed a template based on Jefferies' card idea considering the user role, also called *Persona* (ibid., 97), and the goal a user wants to achieve leading to a certain benefit. (Rubin 2012, 83) In addition, it should contain certain testable acceptance and quality characteristics mentioned on the card's back (Cohn 2004, 13). Jefferies' goal was the initiation of conversations about the User Stories' details. That's why it is also possible to add some additional information to it, which should, however, be limited. (Rubin 2012, 83–85)
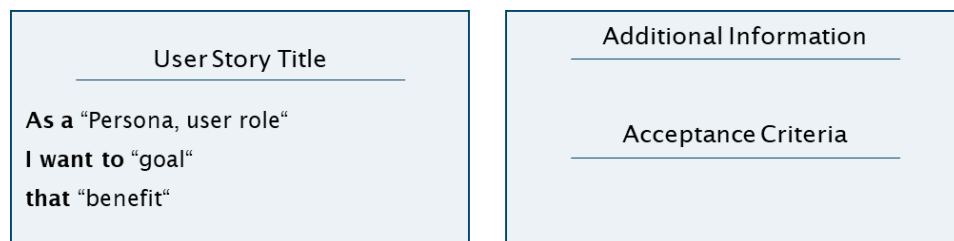
Figure 9. User Story card
(based on: (Rubin 2012, p. 83))

Next to the functional features making up a product, there are other types of requirements. *Technical requirements*, like the intended support of software by different web browsers, don't have a direct value for the customer, but need to be addressed to ensure the functionality of other requirements (ibid., 83). Besides, features which have been developed already, but didn't succeed in the testing, are

marked as *defects* to show the necessity of a refinement (ibid., 100). Furthermore, there is the possibility of a *knowledge acquisition request* filling lacking information about certain products or processes (ibid., 83). According to Rubin (2012, 93), all those types can be still written as User Stories and integrated into the backlogs (ibid., 100).

Process

The User Stories are created as a part of the first step in the Scrum process, based on the Product Owner's product vision. The creation can be accomplished with the support of collaborative workshops between the Scrum team and involved stakeholders. (ibid., 95) Another approach, which was developed by Jeff Patton, is the *story mapping* implementing the defined User Stories into a map based on their priority and chronology. (ibid., 96–97)
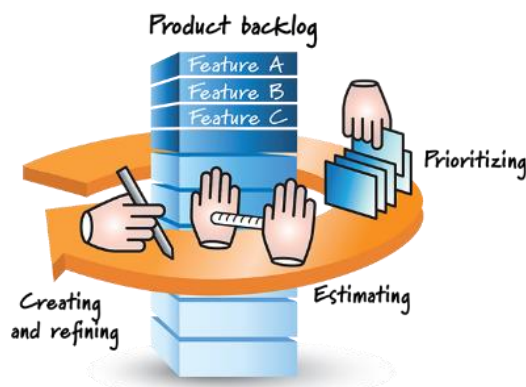
Figure 10. Product Backlog Grooming
(Rubin 2016)

As figure 10 shows, this procedure combined with the Story's implementation into the Product Backlog, as well their estimation and prioritisation is called **Grooming**. Considering the prioritisation procedure, several authors can be identified sharing the same opinion. As an ongoing action, prioritisation leads to a specific order of requirements within a backlog. Consequently, the ones with the highest value combined with other criteria, like costs or risk, have to be developed first. (Preußig 2015, 95–96) According to Preußig (2015, 139), the choice of order can additionally be exclusively in the hands of the customer. It is also essential to estimate the size of aser Story. This needs to be accomplished to receive information about their development costs. Due to a low detail level of the User Stories in this process phase, it is possible to simply compare them relatively to each other. (Rubin 2012, 19–20) Another approach handling the estimation, is the *Planning Poker*. Moderated by the Scrum Master, Fibonacci cards (see Appendix A.2.2) are used to get a rough time or

complexity estimation of a Story. At first, the Product Owner explains a User Story to the Development Team. The members, subsequently, choose a card number based on their opinion to estimate this Story. If opinions differ, explanations therefore have to be given. Afterwards, further estimation rounds follow until a common number can be agreed on. This number can be related either to *person days* or *story points*, which represents the abstract complexity in comparison to other Stories. (Preußig 2015, 99–102) For first rough estimations in practice scenarios, t-shirt sizes like small, medium, large, etc. are usually used (Blankenship et al. 2011, 83).

Before the actual developing during an iteration ramps up, the User Stories which are going to be implemented have to be chosen. This happens within the **Sprint Planning** already being a part of a Sprint. It is performed by the whole Scrum team. Whereas the Scrum Master is responsible for the planning process, the Product Owner and the Development Team decide about the exact content. (Rubin 2012, 21–22) At first, Sprint goals are generated on which base a part of the Product Backlog's User Stories are chosen. Thereupon, the team fills the Sprint Backlog with the most valuable Stories, and breaks them down into more detailed tasks to enable their accomplishment during one sprint. (Blankenship et al. 2011, 19) For this procedure, Preußig (2015, 97) highlights the importance of considering correlations between certain Stories. These correlative Stories are called *minimally marketable features*", because, together, they already form the basic sellable sub product.
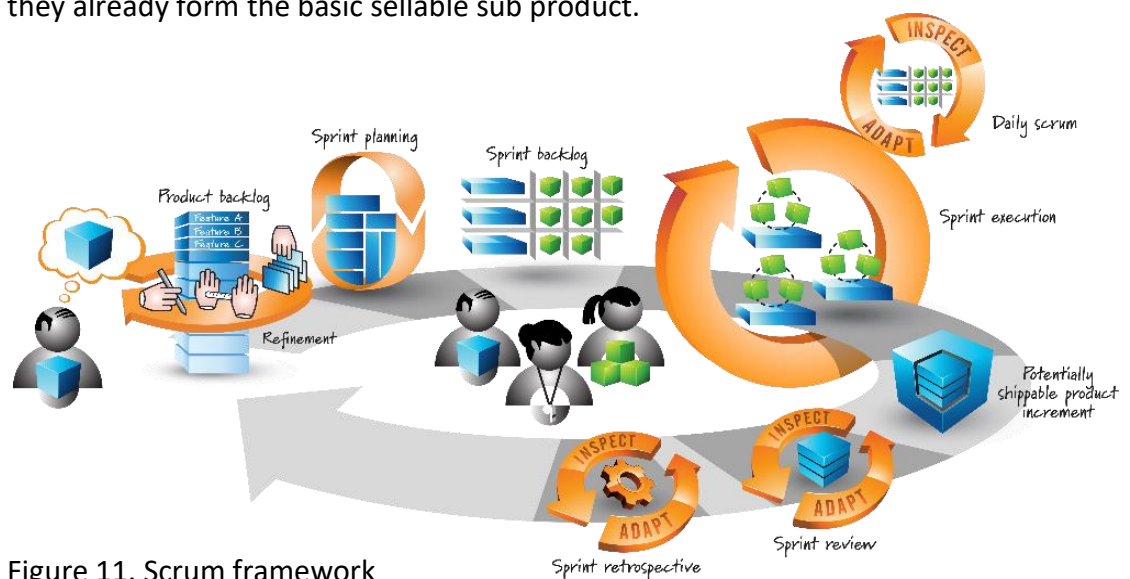
Figure 11. Scrum framework
(Rubin 2007-2017, chapter 2)

Illustrating the entire Scrum framework, figure 11 leads to the subsequent **Sprint Execution**, which contains the Development Team's objectives for developing the

increment. Performing the development, it is up to the team members, how and in which order the User Stories are developed. Meanwhile, the Scrum Master examines if the Scrum's values and principles are complied. (Rubin 2012, 23) Tracking the Sprint's progress can be done with the help of a *burndown chart*, which is illustrated in appendix A.2.3. It shows the remaining time and workload based on story points which is contrasted to the time and workload target. Consequently, possible problems are indicated. (Blankenship et al. 2011, 20) Occurring problems are addressed during the **Daily Scrums**. Those short meetings have the goal to coordinate actions against them, but also to receive general status updates. To be efficient, the meetings are done as a stand-up as well as timeboxed with a duration of 15 minutes. To facilitate the procedure, they need to take place during the same time slot and the same location every day. (Preußig 2015, 149–150)

For implementing the User Stories, the Scrum team has defined acceptance and quality criteria being able to recognize, when the increment is entirely done. That is why for closing the Sprint Execution, all members have to agree on the fulfilment of the *Definition of Done*. (ibid., 114)

After the increment is declared done, two other meetings take place to complete a Sprint. The first one is called **Sprint Review**, which is used to present the Sprint's result to active (pigs) and interested (chicken) stakeholders. In case the customer is satisfied, the process can be continued. If, however, change requests appear, they will be put into the Product Backlog and once again prioritised. The same pertains to User Stories which weren't developed due to the limited time. (ibid., 150)
Due to the variable content scope of Scrum projects, additional features, if they don't replace a similar one, lead to an increase in time or resources. Nevertheless, the constraints can be still preserved by deleting or postponing a less important Story. (ibid., 30)

The second meeting doesn't regard the Sprint's content, but the process and methods being used during the development. During the **Sprint Retrospective**, the Scrum team inspects the process and used methods to identify possible issues, which could be improved in the following Sprint. (Rubin 2012, 27–28) The improvement action planning is followed by a next Sprint, being initiated again with the Sprint Planning

(ibid., 21). This procedure continues until the time and resource constraints are reached, and either the last increment or the final product can be released.

3.2.2 Dynamic Systems Development Method

A similar approach is the **Dynamic Systems Development Method**, or short DSDM. It was created in the year 1994 by representatives of several information technology organisations, who commonly formed the non-profit *Agile Business Consortium*. (Stapleton 1998, xiii) Their original goal wasn't to define a new agile approach, but to create a common tailorable environment for the *Rapid Application Development* (RAD) approach. At that time, it just offered situation-based tools and processes (ibid., xiv–xv) for user-integrated software development (Mackay et al. 2000). For that reason, Stapleton (1998, xiv) calls DSDM a "… framework of controls for RAD…", made out of best practices (ibid., xvi). In 2007, DSDM was published as an own approach, being since then continuously refined. Its latest version was announced 2014. (Craddock et al. 2014, 1)

Values and Principles
DSDM's approach is, in common with Scrum, seen as philosophy based on a clear strategy, which focuses on frequent deliveries. As part of the philosophy and their status as one of the four value piles, people are in the centre. Next to them, practices, as well as the process and its *products* represent the other three values. (ibid., 3.1) DSDM adds eight principles to the philosophy for aiming the values' implementation. Most of them, for instance, focusing on the business value, collaboration and good communication; are adopted from the Agile Manifesto. Additionally, with the focus on punctual delivery and the demonstration of control, DSDM mentions two further principles. (ibid., 4.1) The latter one is described essential for raying out trust and transparency to the involved stakeholders by showing that everything is under control (ibid., 4.9). Even though the consortium claims that the philosophy has to be used as a whole not to risk reaching the goals (ibid., 4.1), the punctuality is indicated as the "…single most important success factor" (ibid., 4.3). A related compromised success occurs especially if the value of the product is linked to the time deadline (ibid.). However, DSDM wants to prevent this scenario through fixing the project's ariables of time, cost and quality, whereas the content of the project outcome remains

variable. That action helps to always adhere to deadlines by reducing the content if difficulties during the process occur. (ibid., 3.3)

Roles   Implementing the values and principles is up to the philosophy-centred people. DSDM has therefore defined several roles concerning different project areas. As shown in figure 12, they are split into business interested (orange), solution interested (green), management interested (blue) and process interested (grey) areas. There are also roles with two different interests (color mix). (ibid., 7.2.1)
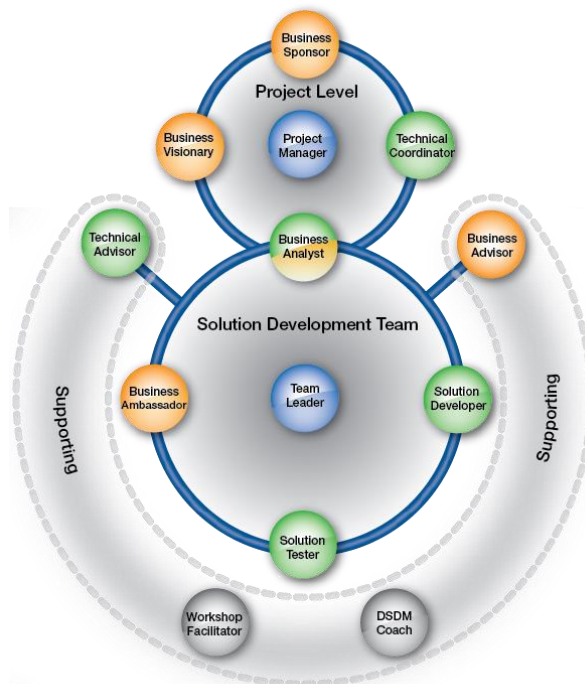
Figure 12. DSDM roles
(Craddock et al. 2014, 7.1)

Compared to the Scrum roles, DSDM defines a wider range of people involved in a project. The consortium divides them into governing responsibilities (ibid., 7.2.2.1) on the one hand, as well as performing (ibid., 7.2.2.2) and supporting (ibid., 7.2.2.3) responsibilities on the other hand. The first role with governing responsibility is the **Business Sponsor**. He is responsible for the business case as well as the budget for the project. As the Sponsor represents the business interests on the highest level, the person filling this role has to be empowered to decide about financial issues not to risk a fast project implementation. A single person for small projects or a board including a chairman for bigger circumstances can either fulfil it. (ibid., 7.3)

The **Business Visionary** is responsible for designing and communication the business vision of the project, which is based on the Sponsor's business case. The vision consists of essential high-level requirements to enable a strategic direction for the team, and also concerns their resources. He has to ensure that the results are aligned with the vision, being able to guarantee the Sponsor's calculated benefits. Consequently, the Business Visionary has to adapt his vision if conditions change. (ibid., 7.4, 7.4.1)

The technical counterpart is up to the **Technical Coordinator**, who is accountable for technical aspects and their coordination, like the right architecture for software projects or technical practices for the development. Moreover, he functions as advisor for the **Solution Development Team** as well as supports the implementation of the vision in collaboration with the "**Business Analyst**". (ibid., 7.5, 7.5.1) As intermediator between the governing and performing roles, but also between the business and technical interested areas, the Analyst supports the team and their comprehension of business aspects, so that those can be matched to the technical solution. He, furthermore, controls qualitative aspects and the implementation of non-functional requirements. (ibid., 7.7, 7.7.1) As governing head of the Team, the **Project Manager** is responsible for the deliverable product. He, though, just manages it on a high-level implying that the actual development is up to the team members themselves. Nonetheless, he is still in charge of tracking the progress and managing risks and problems. That is why he has to ensure, while communicating with involved stakeholders and the team to develop a high-level plan, the DSDM principle of demonstrating control. His tasks can either be accomplished by a business or technical employee, and additionally with a collaboration partner, e.g., if parts are developed by a supplier. (ibid., 7.6, 7.6.1)

Within the project development team, the **Business Ambassador** has a big influence on the product's business requirements and their alignment with the technical development. Besides, his tasks include the testing of economic criteria and the provision of training for business roles of the solution in-use. (ibid., 7.9, 7.9.1)

The **Solution Developers** perform the actual product development by creating technical solutions out of business requirements. In collaboration with other team roles, they do not only generate the product increments, but models and development documentation as well. That is why they have to be able to make decisions about the

concrete outcome of their solutions. Before releasing an increment to the **Solution Tester**, Solution Developers, moreover, have to pre-test its technical functions and quality. (ibid., 7.10, 7.10.1) As the third role in the team, the Solution Tester verifies the increments based on the defined acceptance criteria and their testing strategy, and also supports the Ambassador in his testing. (ibid., 7.11, 7.11.1)

Being the communication and escalation connector between the Project Manager and the team, the **Team Leader** is responsible for the team's progress and motivation. Usually executing another role within the team, he leads meetings and controls the process. (ibid., 7.8, 7.8,1) The Leader and his team members get support of **Technical Advisors** and **Business Advisors**. They provide their knowledge for the requirement creation, support decisions and create documentation files. (ibid., 7.12.1, 7.13.1) Planning and post-processing workshops, which are a practice of DSDM, is in the hand of the **Workshop Facilitator** (ibid., 7.14.1). The definition of supporting roles is closed with the last role, the **DSDM Coach** who is supporting roles without a big experience as well as promoting the reasonableness of the approach to other stakeholders and parts of the company. (ibid., 7.15, 7.15.1)

Practices

Aiming to fulfil DSDM's principles of collaboration and continuous and clear communication (ibid., 4.1), the DSDM roles are supported, among others, by three practices. **Facilitated Workshops**, as the first, enable improvement in both. Due to the collaboration of each necessary stakeholder for the accomplishment of tasks, like planning or the idea generation, faster decisions can be achieved. (ibid., 9.1) Owing to a collective participation, misunderstandings can be prevented and occurring problems can be solved immediately, whereas they normally have to be discovered first to hereafter fix them through a slow escalation process. (ibid., 9.2) The Workshop's greatest utility is reached through the independent Workshop Facilitator's support for the *Workshop Owner* in reaching his planned outcome. Fulfilling the roles, he has to take care of the workshop process, as well as filling the role of a moderator. (ibid., 9.3.3.1) Subsequently, the participants have to create the content and make decisions to accomplish the Owner's goals. (ibid., 9.3.3.3)

The second practice takes advantage of different kinds of models during the development process. Craddock and colleagues (ibid., 12.1) highlight the characteristics of

Modelling which lead to a facilitated communication through visualisation and transparency of project ideas. In a further phase of the project, overviewing prototypes and mock-ups can reveal coherences between requirements as well as between business needs and technological standards. This enables improved task generation for the actual development (ibid., 12.4.3). It is furthermore useful to create, e.g., process models to clarify, how increments and the whole solution are going to be put into operational use (ibid., 12.4.4).

Embedding collaboration and communication supporting practices, DSDM uses iterations to carry out the agile development (ibid., 11.1). Comparable with Scrum's Sprints, DSDM's iterations are anchored in **Timeboxes**, which have a fixed duration (ibid., 13.1). Each Timebox's outcome is, in contrast to Scrum, not a complete Increment. As a consequence, several Timeboxes, or one encompassing Timebox, contribute their partial solution for one Increment (ibid., 13.7). Besides, a *DSDM-style Timebox* is described consisting of five parts taking place in an optimal duration of 2–4 weeks. Figure 13 displays a *Kick-Off* as its first step that is followed by the *Investigation* clarifying the deliverables and their quality criteria. During the *Refinement*, which takes approximately 60–80% of the time, the requirements are developed and tested. In the next steps, acceptance criteria need to be verified, before the next Timebox follows. (ibid., 13.3) DSDM also offers the opportunity for another Timebox style, in which the activities in between the Kick-Off and Close-Out can be individually configured (ibid., 13.4).
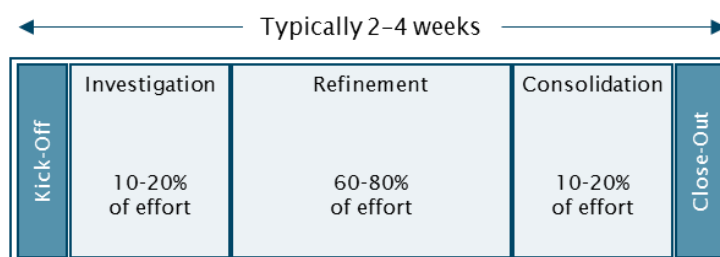
Figure 13. DSDM-style Timebox
(adapted: (Craddock et al. 2014, 13.3))

Process   Notwithstanding the above Timebox configurations, they provide a foundation for the agility in the DSDM process (ibid., 4.1). Due to DSDM covering the whole project cycle (ibid., 1), the process is initiated with a **Pre-Project Phase**. It assesses if the chosen project idea fits into the product portfolio and has clear goals which are alignable

with the strategy's objectives. (ibid., 6.2) This overviewing project definition is registered in the *Terms of Reference* product, which can be, e.g., a formal documentation file (ibid., 8.2.1).

Based on the Sponsor's budget and first project directions (DSDM Consortium 2008, 6.3.2), the **Feasibility Phase** has to confirm the project from a technical and a business perspective. The latter one is expressed in the *Business Vision* (Craddock et al. 2014, 8.2.2). Besides, the *Prioritised Requirements List* (PRL) is created and continuously revised to clarify the content scope for the project (ibid., 8.2.3) It is filled with requirements in the exemplary form of User Stories (ibid., 15.3), starting with the first few epics during the feasibility phase (ibid., 15.4.1). If the two products confirm the idea's feasibility in both perspectives, the project will be continued. Alternatively, if the risks contrasted to the technical implementation complexity and the costs are yet too high (ibid., 16.6.1), the project won't be passed to the next phase. (ibid., 6.3) Before the process can continues, it is necessary to set up a rough schedule for the project as well as a plan describing among others timeframe and resources for the next phase. (ibid., 16.5.2)

Making it to the **Foundation Phase**, which in small projects can be combined with the previous phase, the project is investigated in more detail. This means that the basic idea of the project has to be clarified being able to create rough solution possibilities and development methods implementing them. Moreover, questions about responsibilities and the DSDM influence have to be addressed. (ibid., 6.4) On basis of the project's mindset and the PRL, requirements that are detailed enough to fit into an iteration are generated (ibid., 15.4.2). Quality criteria, as one of three project constraints, are likewise added to them (ibid., 16.6.2).

Analogous to Scrum, the requirements or Stories have to be estimated and prioritised. Constructing on the feasibility's rough project schedule, they can be sized up by comparing current requirements with experience values from earlier projects. Otherwise, this can be performed using methods like Planning Poker (described in chapter 3.2.1, appendix A.2.2). Craddock and colleagues (2014, 16.2.3) suggest to additionally refine the result with a second approach, which accurately evaluates a few chosen Stories and their tasks.

Whereas Scrum prioritises and sorts by value, a special method, which was developed by one of the consortium members (Stapleton 1998, 28), is provided by DSDM. It is called *MoSCoW Prioritization*, and clusters the requirements or User Stories by *Must Have*, *Should Have*, *Could Have* and *Won't Have* this time. (Craddock et al. 2014, 10.1) Without the Must Haves, which build the *minimum usable subset* (must) (Stapleton 1998, 29), the solution would malfunction. That's why they are contractually fixed as guaranteed solution characteristics (Craddock et al. 2014, 10.2.1). With a lower value to the final product, the Should and Could Haves are still important, but won't risk the success of the product. Depending on the impact leaving them out, they are added either to the Should Have's (higher impact) or to the Could Have's (lower impact). The latter ones are part of the most opportunistic solution and, consequently, aren't implemented if the time constraint is reached. (ibid., 10.2.2, 10.2.3) Won't Haves are decided in advanced not to be part of the solution, but help to recognize all possible coherences between requirements. Nonetheless, they can be chosen as parts for further solutions (ibid., 10.2.4). For the prioritisation process, Craddock and colleagues (2014, 10.8) recommend starting with all requirements clustered as Won't Haves to then bring their contribution to the solution into question. This process is applied at first to the PRL requirements, and later on also for the increment and Timebox level (ibid., 10.3). As a result, Must Haves should be limited to 60% and Could Haves to 20% of the total necessary implementation time, providing a guarantee of their delivery while having a certain amount of flexibility. (ibid., 10.4.1)

Afterwards, it is the goal to generate a preliminary *Delivery Plan* product with an overview of the increments and a rough schedule for the first Timeboxes (ibid., 8.2.6). Before the process continues, the defined products like the Business Case, the PRL, or others like the Solution Architecture Definition, describing the rough solution layout (ibid., 8.2.4), and the *Management Approach Definition*, including the project administration and planning methods as well as stakeholder intersections, have to be analysed and approved. This happens, analogous to the Feasibility Assessment at the end of the feasibility phase (ibid., 8.2.8), in the *Foundation Summary*. Both, among others, are milestone products requesting a decision, whether to proceed, rerun the phase or drop the project (ibid., 8.2.9)

As figure 14 illustrates, the **Evolutionary Development Phase**, as following process step, takes place as an iterative development. Before the team develops increments in order to provide their matching input for the e*volving solution* (ibid., 8.2.10), their Timeboxes have to be framed. This frame is, under the control of the Team Leader, documented in the *Timebox Plan*, which consists, among others, of the intended goals and requirements planned to be accomplished and implemented, respectively. (ibid., 8.2.12) Being able to develop and test the requirements or User Stories during the steps of a certain Timebox later on, they have to be chosen from the prioritised PRL and hereafter specified (ibid., 15.4.3). This can be processed by subdividing the Stories into smaller Tasks, enabling their assignment to single responsibilities (ibid., 16.5.4). Before the actual execution is initiated, the tasks have to be prioritised again, based on the Timebox duration (ibid., 10.3).
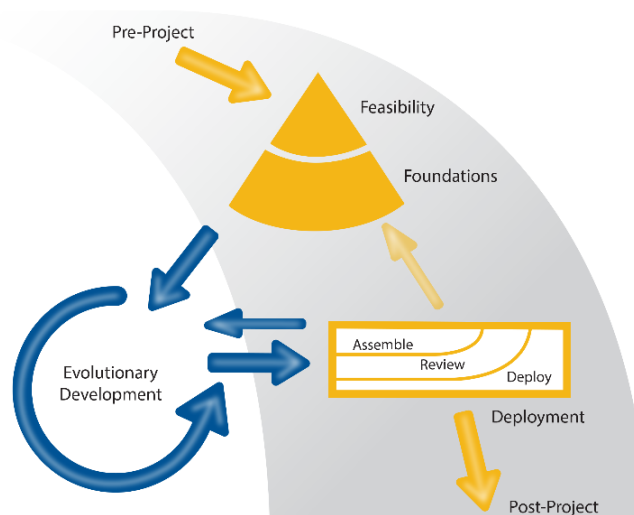
Figure 14. DSDM process
(Craddock et al. 2014, 6.1)

The transformation from a User Story into a partial solution can be achieved using different strategies, which were planned for the *Development Approach Definition* during the Foundation (ibid., 11.2). Craddock and colleagues (2014, 11.2.2) characterise software products and partly non-software products as solutions consisting of several architectural layers. These layers can therefore be either approached vertically (completing a layer before the next), horizontally (completing a function concerning several layers before the next) or as a mixture of both. In contrast to the other two, the latter one offers advantages, like both a fast impression of the whole solution and possible sales of increments, without showing disadvantages. (ibid.)

For the purpose of tracking the development progress and identifying issues, *Daily Stand-Ups*, as part of the Timebox, are held in manner of Scrum (ibid., 13.5). Likewise, the Timeboxes are closed by fulfilling its defined quality criteria (ibid., 16.6.5) as well as reviewing the result against the vision, and the process during a retrospective (ibid., 13.3). Each result is saved in the *Timebox Review Record* (ibid., 8.2.12).

When the increment was successfully developed, tested and reviewed; it has to go through three more steps during the **Deployment Phase** to be put into use either individually or embedded in the complete product (ibid., 6.6). At first, every available input, like the increment and its complimentary information, e.g., training plans or manuals have to be consolidated and *assembled* (ibid., 6.6.1). Afterwards, the partial or complete solution has to be tested in its final environment (ibid., 16.6.6), *reviewed* and approved. During the subsequent *deployment*, the solution is installed, and related tasks, for instance, user trainings, are performed. (ibid., 6.6.2-6.6.3) Each review result and outcome of a retrospective (ibid., 6.6.2) for either an increment or the completed project is saved in the *Project Review Report* (ibid., 8.2.13), which will be used for product and process improvements for next Increments or projects (ibid., 6.6.2). Starting the next cycle for another incremental development, a return to the foundation phase should verify the project's business case (ibid., 8.2.2) to subsequently identify and prioritise requirements for the next Timeboxes (ibid., 16.5.7).

Finally reaching the time constraint, the project is closed with validating the predicted project profit and other benefits during the last process step, the **Post-Project Phase** (6.7). For this purpose, the *Benefit Assessment* product is used, and applied schedule-based to the expected benefit occurrence (ibid., 8.2.14).

3.2.3   Kanban

The third and last approach is **Kanban**. The word originates from the Japanese terms *kan* and *ban*, which mean *signal* and *card*. Those signal cards were originally used in the *Toyota Production System* (TPS) helping the workers in ensuing production steps to recognize, when the previous process step is completed. Through the limitation of those cards, problems can be discovered owing to employees who cannot perform their work without a signal card. This principle is called *pull system*. (Leopold,

Kaltenecker 2013, 11) Even though *Toyota* had employed this principle already to advantage, David J. Anderson based his development of the Kanban project management approach on the *Theory of Constraints* by Eliyahu M. Goldratt, who also recognized the effects of the pull system (ibid., 11–12). This results in a spelling difference. Whereas the *k* in the original method is written with a minuscule, the one in the project management approach differs in using a majuscule (Anderson 2010, 6). Anderson (2010, 6) justified this in describing the new project management approach as an "… evolutionary change method that utilises a kanban pull system, visualisation, and other tools…" . It was developed in the year 2004 and originally used for information technology projects at *Microsoft* (ibid., 5).

Values and Principles	Due to the TPS analogy, Kanban shows values and principles stemming from the *lean thinking* (Kniberg, Skarin 2010, 35). Anderson highlights five of them in particular (Anderson 2010, 15):

- "**Visualize Workflow**", also described as "**transparency**" (ibid., 55)
- "**Limit Work in Progress**"
- "**Measure** and **Manage Flow**"
- "**Make Process Policies Explicit**"
- "**Use Models** to **Recognize Improvement Opportunities**"

The latter *property*, as he describes values and principles (ibid., 15), is also part of the *kaizen* principle, which takes advantages of improvements continuously (ibid., 6).

Due to its execution of lean principles, there are different opinions about Kanban being considered as an agile approach. Preußig (2015, 119) declares it as a lean method, because of its focus on the optimisation of the workflow. Due to Kanban's lean principles like the pull principle or the aim for continuous optimisation, and its agile value of focusing on responding a change rather than following a plan; Kniberg and Skarin (2010, 35) think about it as mix of both. Brechner (2015, 121) sympathises with their view. Nevertheless, it was integrated into this approach illustration due to Kanban winning an award for its agile input to the *Agile Alliance* (Anderson 2010, 7), as well as Anderson's original goal of Kanban to improve the agile idea of a *sustainable pace* for the employees (ibid., 2). This pace was according to him, promised by other agile approaches with limiting a small amount work to a defined period of

time. It, however, didn't show any effect due to a general, steady increase in the workload within iterations of agile projects. (ibid.)

Roles

In contrast to Scrum and DSDM, Kanban doesn't provide any specific roles. Kniberg and Skarin (2010, 11) claim that roles aren't defined, but can be chosen individually. In addition, Anderson doesn't devote himself to roles explicitly. During his practice examples, the former roles stay within the process, but are assigned to different tasks (Anderson 2010, 36–38). This is reasoned by Kanban's and kaizen's goal of not exchanging the whole process and its responsibilities, but to change the organisation culture in order to improve existing processes. Anderson justifies this difference to other agile approaches, like Scrum or DSDM, with the intention of minimising change impacts and reducing organisations resistance for changes. (ibid., 50–51) Notwithstanding both authors' ideas of Kanban roles, Epping (2011, 79) mentions two roles in the Kanban approach. The first is the project management team, subsequently the Kanban team, or contractor. The other one is the customer or purchaser, who can be involved in different ways. As illustrated in figure 15, he can either ignore how the product is developed, supporting the Kanban approach passively by acknowledging it, or supporting it actively. The latter way leads to a customer, who becomes a member of the Kanban team (ibid., 82–83). In a practice example, Epping (ibid., 86), moreover, divides the Kanban team into one person being responsible for the requirement engineering, four persons for the development, one to two persons for quality management and another person for the project management.
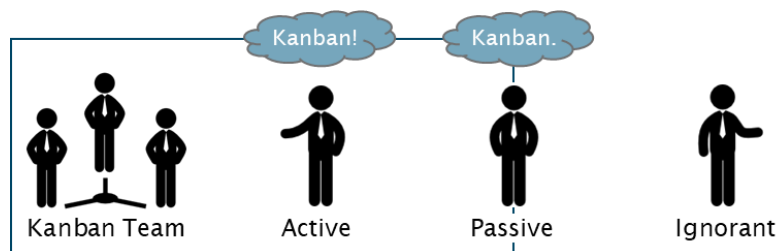
Figure 15. Possible Kanban roles
(adapted: (Epping 2011, p. 83))

Practices

Whereas Scrum and DSDM are focused on the roles having a process which is built around them, Kanban offers a practice which is in the centre of the process (Kniberg, Skarin 2010, 28). The one everything is based on, is the **Kanban Board** (ibid., 15), also named **Card Wall** (Anderson 2010, 65). It shows the different stages in either both or either a physical, like in figure 16, or an electronic way (Anderson 2010, 72; Epping

2011, 115). Illustrating, e.g., a development process, it can include activities (Anderson 2010, 65), and also queues (Kniberg, Skarin 2010, 47). Latter ones wouldn't be needed for a perfectly working process (ibid., 44), but are utilised to smoothen the workflow in case of an issue occurrence. A pulling effect delay with employees waiting for their next task can be prevented in this way. (Epping 2011, 117) The physical example of a Kanban Board in figure 16 shows that the activity and queue overviews are visualised in columns (Kniberg, Skarin 2010, 65). The two on the extreme left side deliver the input for the process and are therefore called input queues. In this particular case, the *Backlog* lists all possible requirements, whereas the *Selected* column shows the prioritised ones that are ready to be processed. (ibid., 42) Nonetheless, it is possible to combine them into one column (Anderson 2010, 66) if, e.g., a prioritisation isn't necessary and the *first in – first out* principle (FIFO) is applied (ibid., 70). Besides, certain activities can be divided into sub stages, like the pictured *Ongoing* and *Done* (ibid., 67). The Done queue helps to neutralise variability in the finalisation of tasks. Additional buffers in front of time-consuming activities, so-called *bottlenecks*, can moreover lead to an improved smoothness of the process. (ibid., 115)

| | Backlog | Selected 2 | Develop 3 | | Deploy |
			Ongoing	Done	
I	F	D ----▶		B	A
II	G ...	E		C	
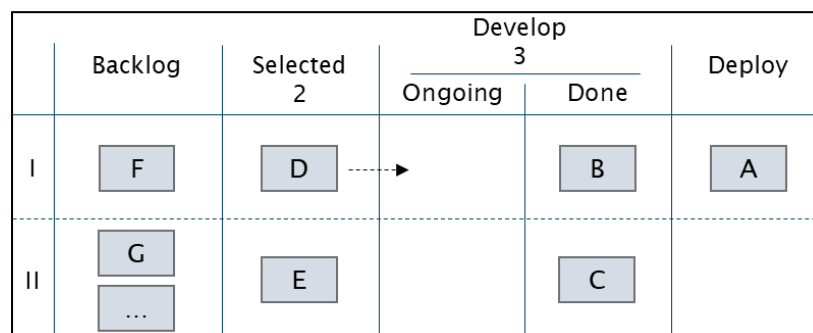
Figure 16. Kanban Board example
(based on: (Kniberg, Skarin 2010, p. 42))

The smoothening of the workflow can be facilitated by **Cards**, which are outlined by rectangles pointing out a single letter in figure 16 (Kniberg, Skarin 2010, 34). These kanban illustrate the project components as workflow *items* on the board (Anderson 2010, 70). According to Anderson (2010, 93) and Epping's (2011, 89–91) role, who performs the requirement engineering; those items can be described in User Stories having INVEST characteristics. Thereof, *independent* and *small* are the most important ones for the facilitation and the smoothening of the workflow (ibid., 72). Besides, also the *testable* characteristic is essential for the team members being able to

know when an item can be pulled into the next workflow column. An item's *Definition of Done* or *Pull Criterion*, which defines the quality and acceptance criteria for the completion of each workflow step, represents this characteristic. (Brechner 2015, 13)

As main part of the pull and the transparency principle, the Card's design is essential. They are the main source for information on whose base the team's decision concerning the process are reached. Anderson (2010, 70–71), moreover, describes them as the foundation for the team' self-organisation. (ibid.) Due to its importance, both Anderson (2010, 70–71) and Epping (2011, 115–116) recommend a good working appearance. Comparing their suggestions, it can be perceived that a good Card should have the following characteristics:

- Own **identification number**
- Short **description** of the requirement
- **Date** of **workflow entrance**
- **Persons**, who were **responsible** during the workflow

Besides the common characteristics, Epping (2011, 116) suggests adding the planned and actual effort for the items as well as their delivery date to the card. Anderson's Cards, in contrast, have an additionally added fixed end date for the requirement, as well a mark, in case of a delay. Furthermore, he recommends certain positions for the characteristics on the card. Those are illustrated in figure 17. (Anderson 2010, 70–71)

Card ID	Item Name	Delivery Date
Requirement, change request, etc.		
Start Date	Responsible Person	Delay Mark

Figure 17. Kanban Card
(based on: (Anderson 2010, 71))

If different *Work Item Types* such as new requirements, change wishes, or service requests, exist simultaneously during a project, their differences are recommended to be shown, e.g., in different Card designs. (ibid., 64–65) Also, *Swim Lanes*, diving the

Kanban Board horizontally (see Figure 16), as another option of visualising the differentiation between items can be approached. They can moreover be used for the handling of several project at the same time (Kniberg, Skarin 2010, 34).

The third practice, which is premised on the Cards in the Kanban Board's workflow, implements the principle: limit *Work in Progress*. **Limited WIP**, furthermore, makes the difference between task boards, which can be used for task tracking in Scrum or DSDM, and the true Kanban Board (ibid., 15). It is based on the theory of constraints, which in this context says that a process can only be as fast as its slowest constraint (Anderson 2010, 117). That is why these bottlenecks have to be discovered and smoothed away (ibid., 4). Kanban, therefore, reacts on this rationale with individually limiting the number of requirements within all or most of the workflow columns. If the limit is hit, a possible problem can be discovered and solved immediately (ibid., 117–118). Besides this early identification and prevention of temporary constraints, the limits enable a sustainable pace due to reduced interruptions in the workflow (ibid., 4). Another advantage of a limited WIP, is according to Anderson (2010, 28) a shorter development lead time and an improved item quality. Nevertheless, it is still possible to have unlimited WIP for certain steps, e.g., for the delivery queue enabling its filling with all comprehensive requirements (ibid., 120). In figure 16, as an example, the WIP is shown with numbers underneath the column description. The limiting amount per workflow column can be related to the amount of Cards if their requirements have approximately the same effort size. With a widely differing size, a limit based on Story points is possible. (Kniberg, Skarin 2010, 16) The practice can be moreover applied to Swim Lanes to match the limit of each step to the available Swim Lane capacity (Anderson 2010, 120).

Process

Due to the WIP's dependence on project and team characteristics, like the amount and knowledge of employees, the project schedule or its extent; the work in progress differs for every project. Subsequently, the WIP limit has to be reconsidered at the beginning of each Kanban process. (ibid., 4) At first, however, the actual process has to be illustrated (Kniberg, Skarin 2010, 4) using the method **Value Stream Mapping** (Anderson 2010, 63). For an easier implementation of the Kanban approach, Anderson (2010, 63) mentions, in this context, the importance of the team honestly visualising the used process, instead of the one they officially should work with. To

receive an overview, the process should be demarcated by determining a starting point and an endpoint as well as stakeholder intersections. Those can be, for instance, the item input from higher level partners and the delivery output for the production department. (ibid., 64)

When the single activities of the process become clear, they can be visualised on the Kanban Board column by column. (ibid., 64–65). The workflow should also consist of queues, which can be either illustrated as an additional column or integrated into an activity by dividing it into two sub columns. Anderson (ibid., 67) recommends the usage of names like *In-Progress* and *Done* for the purpose of building queues. In case of special activities correlations for a certain Item, the columns can be further specified. The simultaneity of two activities, as the first specialty, can be either solved by integrating both activities into one column, or by subdividing a column into the different sub activities. The latter solution leads to a temporary split of the Card into a certain number of sub activity related Cards until each sub activities is completed. (ibid., 73–75) The second specialty concerns Cards without a pre-defined sequence of several sub activities. As a solution, either a column just illustrates the overviewing activity and contains Cards, which mention the necessary sub activities; or the column can be divided into sections naming the different sub activities. For the second option, the Cards are moving from section to section being thereafter marked to have each passed sub activity accomplished. (ibid., 74–76)

Before the approach can show its improving impact, the WIP has to be limited as a final step of the Value Stream Mapping. For choosing the limit for an activity, it is useful to choose a number and adjust it based on its impact on the workflow. Anderson refers to a research that recommends having a limit of two items per worker. He, however, reminds that this number shouldn't be more than a guideline due to the differences between organisations, their projects and teams. (ibid., 114) Another limiting method is the usage of high WIP Limits in the beginning, which are continuously decreased. This also facilitates the detection of bottlenecks. (ibid., 67)
Possible buffers, for example, in front of a bottleneck as well as queues, like the Done queue, have to be limited, too. This can be achieved likewise with empirical tests. Those limits prevent the team of standing still and lead to a smoothening of

the workflow. The queue and buffer limits shouldn't be though too high due to the consequent increase in the processes' lead time. (ibid., 115–117)

Besides, there is a different limiting rule for the input queue. Its WIP limit depends on the prioritisation rhythm and the average amount of items a team can develop during a period of time, also called *development speed* (Epping 2011, 106). The limit should be therefore set up as high having enough items to be developed until the next prioritisation meeting takes place. In addition, the limit can be extended by a few additional items to absorb variability. (Anderson 2010, 116) These prioritisation and input queue refill meetings, so-called **Queue Replenishment Meetings** (ibid., 84), are part of the actual Kanban process. Due to the input queue's independence from the actual development (ibid., 93), their rhythm has to be determined at first, and can either be periodic, on demand or ad hoc (ibid., 110). Anderson (2010, 106) prefers the periodic one due to an increased collaboration and trust between the stakeholders. The latter two rhythm types, in contrast, are applicable, e.g., for people working in the same office, making additional meeting redundant (ibid.).

While performing the meetings, it is the goal of high business stakeholders to fill empty input queue slots with new items (ibid., 84). Before this can happen, an order of how to choose the items has to be specified (Kniberg, Skarin 2010, 37). For this purpose, there are several options. Kniberg and Skarin (ibid.) mention, for instance, the possibility of choosing the oldest (FIFO), the newest, a random item or a sequence of items depending on the required capacity of the item types. Anderson (2010, 37) additionally suggests the usage of a voting during the meeting. According to Kniberg and Sarin (2010, 37), a prioritisation of items is optional. If necessary, the items can be prioritised depending on criteria, like risk, their importance or their delaying costs (Epping 2011, 73). In addition, Anderson offers the opportunity of prioritising the items by *Classes of Service*, which are a combination of different criteria (Epping 2011, 74) and provide the customers a flexible and predictable solution for their requirement input (Anderson 2010, 124). He describes four different classes, which are extendable to six:

1. **Expedite Class**: This item is highly urgent due to the exemplary end of the fiscal year, and can replace low value Items reasoned by the *expedite class'* higher

profit. Their WIP limit is normally fixed owing to their radical impact on the work-flow. (ibid., 125) An additional rough estimation is necessary to predict their lead time, which is important for the adherence to the time limit. (ibid., 130)

2. **Fixed Delivery Date Class**: Due to the fixed date of delivery, high costs of delay will occur if the product isn't delivered until the deadline. (ibid., 126–127)

3. **Standard Class**: With the highest amount, these items can be urgent, but with a cost of delay occurring within the request deadline, but after their forecasted de-livery. (ibid., 127–128)

4. **Intangible Class**: The lowest class can be important, but isn't fixed to a close deadline. That is why delay costs won't occur. Intangible items are usually re-placed by higher classes, e.g., the expedite class. (ibid., 128–129)

These classes should be visualised differently, for instance, with different colours or own capacity allocated Swim Lanes (ibid., 137). They, furthermore, replace the need for the estimation of most items due to their consideration of the whole business im-pact, including time constraints (ibid., 124). If one is still required, Planning Poker as a possible User Story estimation method is mentioned by Epping (2011, 93). Anderson, however, recommends it due to a costly gathering of all necessary stake-holders only to small teams. Hence, he suggests no estimation at all for other teams. (Anderson 2010, 108)

After the first Queue Replenishment Meeting leads to a filling of the input queue, the items can be developed. The development starts with the first, still empty activity, which pulls the ready items from the input queue. Finishing this activity, the cards can be pulled into the complimentary Done queue, when the pre-defined Definition of Done is fulfilled (Brechner 2015, 13). This procedure continues iteratively for each item until the last queue is reached. If change suggestions occur during the develop-ment requesting an immediate implementation, they can be exchanged with a less important item in the input queue. Consequently, the item can be immediately pulled into the first activity, when capacity is available. (Kniberg, Skarin 2010, 23–24) The comprehensive developments progress can be visualised in a cumulative flow di-agram (see appendix A.2.4), which also makes the lead time in comparison to the WIP limit visible (Anderson 2010, 27).

Comparable to Scrum and DSDM, Kanban also uses **Daily Stand-up Meetings** during the performance of the value stream. The focus, however, doesn't lay on the progress of the tasks due to the information can be seen on the Kanban Board. The meeting participants concentrate on occurred problem, like a stuck or blocked item and their solution plans. Further detailed discussions can be held in small groups during the ensuing **After Meeting**. (ibid., 82–84) Another meeting, which focuses on occurring problems and their elimination through the workers or escalation paths, is the **Issue Log Review and Escalation**. It should be held either regularly, or on demand for generally low amounts of issues, to achieve a fast continuance of the workflow. (ibid., 87–88)

As a Kanban characteristic, the development procedure is independent and goes on continuously (Kniberg, Skarin 2010). This becomes possible due to the decoupling of the input creation from the iterative development. Due to the lack of timeboxes, also the delivery cadence of increments isn't pre-defined. That is why a specified rhythm for the deployment gets necessary, being able to benefit from the advantages of increments. (Anderson 2010, 92–93) As figure 18 illustrates, it can be likewise regular, demand-based or ad hoc for a low delivery coordination effort. (ibid., 101)
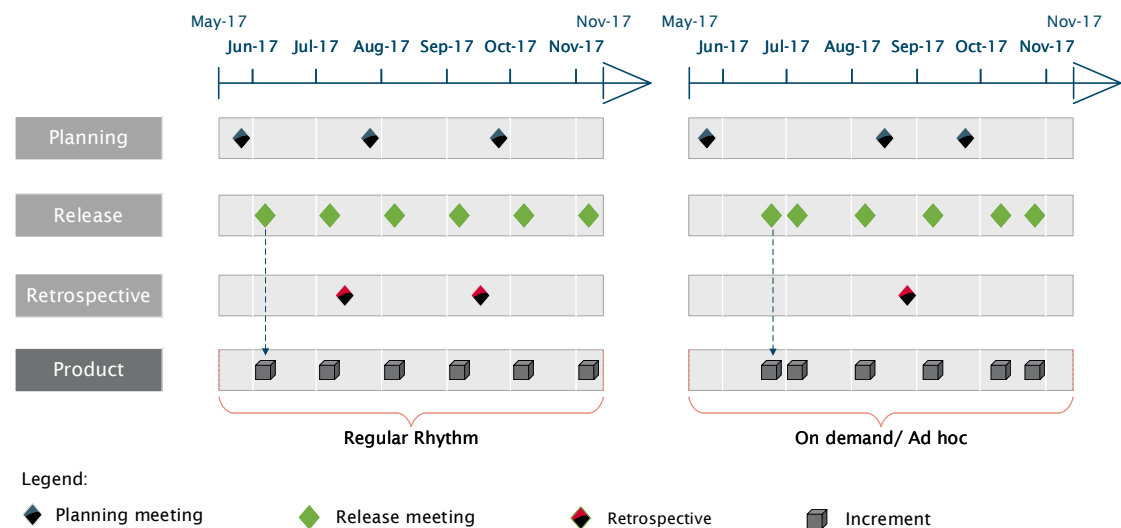
Figure 18. Delivery rhythm: regular vs. demand-based, ad hoc
(adapted: (Kniberg, Skarin 2010, p. 14))

Based on the defined item delivery rhythm and the metric *average completion rate* (Epping 2011, 106), which is based on the item lead time (ibid., 29), the **Release Planning Meeting** offers the possibility to generate release plans for increments or the entire solution. They additionally address, for example, important information for

the release of a sub product or the whole solution into the production. The involved stakeholders' goal is to clarify which completed items can be released, if reviews are necessary and what resources are needed. Depending on the rhythm, deliveries can be regular, on demand or ad hoc. (Anderson 2010, 85–86)

Due to the incessant development of items in Kanban (Kniberg, Skarin 2010, 13–14), also **Triage** meetings have to be set up regularly to review the items in the backlog. During the item review, high business stakeholders have to decide in consideration of each if it should remain in the backlog. (Anderson 2010, 86–87) In addition, Epping (2011, 125–126) as well as Kniberg and Skarin (2010, 13) mention **Retrospectives** as last processes part with the intention to review the Kanban process, which can also take place in a regular rhythm, on demand or ad hoc.

3.3   Comparison and Analysis of the Chosen Methods

Checking all three approaches against each other, it can be ascertained that each of them contains the characteristics of an agile project management framework in a different way. Admittedly, Scrum is described as a management system of a development process (Schwaber 2004, 117–118) and Kanban as a process model (Epping 2011, 68), but they both still consist of roles and practices, which implement the values and principles they are based on, and can therefore be allocated to the APM. Nonetheless, a conclusion reveals the focus of Scrum and Kanban laying on the process. That is why only DSDM with a big portfolio of roles and communication procedures, hence, emphasises the fulfilment of the agile value: "Individuals and interactions over processes and tools." (Cockburn 2006, 367), however; simultaneously offering practices and a project comprehensive process.

Regarding table two, which compares the three approaches based on different criteria, it is visible that Scrum and DSDM pre-define roles in contrast to Kanban. DSDM's bigger portfolio can moreover counter one of APM's critics, which says that it is only applicable to small projects (Seibert 2007, 46–47). DSDM describes itself as an "… easy and effective …" approach for small projects, but it is designed to be geared to big and complex projects (Craddock et al. 2014, 1.1). The critics could be the case for Scrum, which recommends an optimal team size of 2-10 members; but it though offers the opportunity of splitting a big team, into several small teams (Mundra et al.

2013, Abstract). Kanban can counter the critics as well due to the adaptable WIP limit for the activities on the Kanban board, which the roles are aligned to.

Table 2. Comparison of three agile approaches

		Scrum	**DSDM**	**Kanban**
Use	Approach usage	Mainly software projects, but also other kinds of projects possible (Preußig 2015, 7)/ Focus on small projects (observed from optimal team size) (ibid., 42)	Mainly software projects, but also other kinds of projects possible (Craddock et al. 2014, Abstract)/ Small projects possible, but focus on complex corporate ones (ibid., 1.1)	Mainly software projects, but also other areas with lean management (Epping 2011, 34)
	Usage flexibility	Defined framework for process management, and suggested practices (Preußig 2015, 134)/ Individual usage possible, but term transformation to "Scrum But" if changes occur (ibid., 153)	Tailorable framework for agile project management (Craddock et al. 2014, 1.1-1.2)	Process model (Epping 2011, 68) based on the Kanban Board, with suggested practices (Kniberg, Skarin 2010, 10)/ Individual variations (Epping 2011, 2)
Project Variables Triangle		Fixed time, resources/ Variable scope	Fixed time, resources, quality/ Variable scope	Fixed time, resources/ Variable scope
Roles		Three compulsory roles: Product Owner, Scrum Master, Development team (Rubin 2012, 14–15)	13 roles filled depending on the project: Business Sponsor, Business Visionary, Technical Coordinator, Business Analyst, Project Manager, Business Ambassador, Solution Developer, Solution Tester, Team Leader, Technical Advisor, Business Advisor, Workshop Facilitator, DSDM Coach (Craddock et al. 2014, 7.1)	No concrete roles defined, but can be chosen individually (Kniberg, Skarin 2010, 11)

Process		Vision to delivery	Whole project lifecycle	Vision to delivery
Planning		Sprint Planning	Planning of phases, procedures: Solution Architecture, Development Approach, Delivery, Management Approach, Timebox	Queue Replenishment Meeting, Release Planning Meeting
Product Requirements	Creation	e.g., User Stories	e.g., User Stories	e.g., User Stories
	Listing overall/ Iteration	Product Backlog/ Sprint Backlog	Prioritised Requirement List/ Timebox plan	Backlog/ Input queue (if prioritisation is necessary)
	Prioritisation/ Estimation	Based on value, costs, risk, etc./ Planning Poker	MoSCoW method/ Planning Poker	Without, FIFO, Class of Service/ optional: Planning Poker
Iterations	Characteristics	Sprint (1–4 weeks): timeboxed, no breaks between iterations, indirect WIP Limit (ibid., 15)	Timebox (2–4 weeks): high-level Timebox includes several indirect WIP Limit (ibid.)	Length regular (rhythm), on demand or ad hoc, then differing duration
	Structure/ Procedure	No defined structure/ Prioritisation, development, delivery	Timeboxes, DSDM-style or no defined structure/ Prioritisation, development, delivery	Structure defined by activities, WIP Limit/ Development
	Requirement changes	Changes are welcome, but not during a Sprint (Preußig 2015, 154)	Change within planned Timebox scope possible (Craddock et al. 2014, 13.6)	Changes are welcome and implemented immediately, when capacity is available
Delivery of Increment	Increment	Definition of Done: result of one iteration	Definition of Done: result of several iterations with complimentary parts	Definition of Done, Pull Criteria: result of item-based iterations until delivery trigger
	Delivery	After one iteration	After several iterations during the deployment phase	After demand-based requests, or the delivery rhythm

Feedback	Intermediate feedback after Sprint with Sprint Review, Sprint Retrospective (Preußig 2015, 29)	Intermediate feedback after iteration with Timebox Review/ Retrospective, and after increment with Project Review/ Retrospective, Feasibility Assessment, Foundation Summary	Intermediate feedback after retrospectives (on demand/ regular), review feedback dependent on delivery rhythm (Epping 2011, 44),
Other Communication	Daily Scrum, Backlog Grooming	Daily Stand-up, Facilitated Workshop, modelling	Daily Stand-up Meeting, After Meeting, Issue Log Review and Escalation, Triage

Implementation Impact/ Effort	"Dramatic change": New process, little roles, rules, (Blankenship et al. 2011, 15)	Whole framework with big amount of roles, products, practices (Craddock et al. 2014, 1.2)	Improving existing process (Anderson 2010, 51), employees don't have to "change their behaviour" (ibid., 21)

Another critic uttered, is the possibility of using APM approaches exclusively for software development projects (Seibert 2007, 47). It is valid that all three are based completely or partly on the values and principles of the Agile Manifesto, which was found from members of the information technology management. This fact implies a focus on the development of software projects. Nevertheless, they still can be used for other kinds of projects. Kanban, in a similar way, is a popular approach used, e.g., for production processes in the automobile industry (ibid.). Likewise, DSDM and Scrum can be applied to automobile industry. Seifert (2007, 47) mentions in this context, among others, the usage of the *Design to Cost* method which is comparable with the agile project demand triangle. Even though a possible application of the APM to other areas is described as possible, and certain methods are already experienced, a best practice of a complete APM approach for non-software projects is hardly available.

Comparing Scrum, DSDM and Kanban further on, development iterations can be discovered as centre of their agile processes. These, however, are set up differently for each approach. Scrum uses unstructured, timeboxed Sprints, which have a planned scope and a fixed incremental delivery, subsequent to the iteration completion. Likewise, DSDM fixes the duration of each iteration, but delivers incrementally after a

certain amount of Timeboxes. Even though Kanban also takes advantage of the iterative approach, figure 19 shows that Kanban proceeds in a different way. On the one hand, the length can be set up either depending on a rhythm, or on the demand, implying differing iteration lengths. This is achieved by a separation of, the in Scrum and DSDM connected, preparation and development of requirements including creation, prioritisation and estimation and the delivery. On the other hand, Kanban limits the workload per activity through the WIP limit, which is in contrast to Scrum and DSDM solely limited indirectly based on their fixed iterative scope.
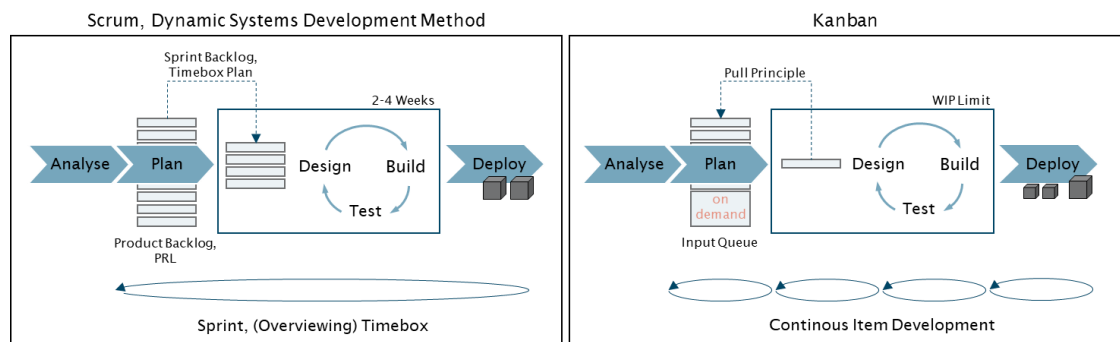

Figure 19. Comparison of Scrum, DSDM and Kanban's iterative development

Before the iterations take place, all approaches perform the in Scrum called Backlog Grooming. Even though, a particular method for how to describe a project's scope isn't compulsory for the usage of any of the approaches, they agree on User Stories as the best option. Regarding the product requirement column in table 2, every approach consequently requires a User Story list to store the entirely possible scope of a product. In addition, another one is required and offered, which demarcates the requirements being developed within an iteration subsequently, on the other hand. For the subsequent estimation purpose, if it is required, Planning Poker is the commonly preferred method, enabling the generation of a high-level plan for the requirement's development. Further comparing the prioritisation of the requirements, five different approaches are identified:

- **No** prioritisation

- **First in** – **first out** prioritisation

- Prioritisation based on **characteristics**, like value, risk, costs, etc.

- Prioritisation with a **combination** of characteristics allocated to classes of service

Analysing the different methods, it is recognisable that prioritising the product requirements with a combination of criteria minimises the risks of, e.g., high costs of

delay as well as a wrong development order, in consideration of the incremental value of backlog items. In this context, Seibert (2007, 47) cites Gernert (2006), who highlights the problems of lacking documentation, like a possible knowledge loss. To reduce this risk, all three approaches describe retrospectives as procedure for reviewing the process being able to improve it for later increments or projects. Nonetheless, just DSDM provides a structured product the Project Review Report to facilitate the documentation. Furthermore, also the possible adoption of other products such as the Timebox Review Record give following iterations and projects a supporting guideline helping to prevent knowledge loss.

Pursuing with the analysis of the summarising implementation effort of the three agile approaches, it is helpful to first allocate them to the basic APM structure. Starting with Scrum and its process range from the product vision to the deployment of the increment, and the complete product, the coverage of the APM intra-project or development level as well as the project level is covered. This is based on Scrum's introduction to new roles which manage the overall success and the process handling the product development. Also, DSDM includes both levels based on the approach covering the process from the vision to the deployment and a portfolio of roles developing the products and managing the project on a higher level. As figure 20 illustrates, the organisational level is additionally broached as a result of DSDM's process giving a guideline for following up on the right project in consideration of decision criteria, like the underlying project portfolio and the organisational strategy. Certain roles additionally offer a connection point for suppliers. Kanban, in contrast, just focuses on the intra-project level. Nonetheless, a high-level management is required for the usage of Kanban in development projects, which is hence provided by the already existing project role and managing structure. Covering the development activities, the Kanban change management deploys in the matter of Scrum, when a decision for a project is made and its vision and scope was clarified.
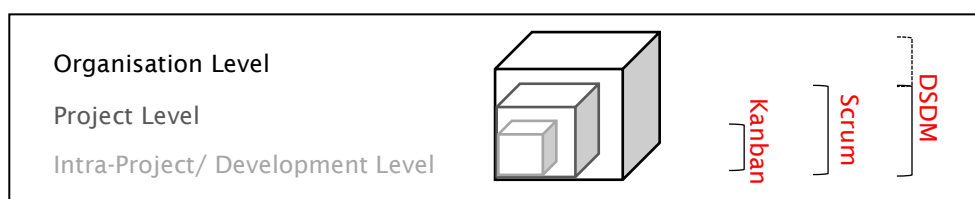

Figure 20. Allocation of the agile approaches to the APM structure model

Based on Scrum's, DSDM's and Kanban's allocation to the APM structure model, implementation impact differences can be deduced. Scrum and DSDM seem to have the biggest impact on the organisation while being implemented, because of their introduction to new roles, new practices and a completely new process. Blankenship and colleagues (2011, 15) confirm this deduction and describe an implementation of Scrum as a "… dramatic change …". Considering DSDM's allocation to all APM levels by offering a complete framework with a bigger number of roles, products and process steps than Scrum; it seems to have an increased impact for the organisation. DSDM tries to encounter this disadvantage with the possibility of an individual tailoring of the approach. This implies that not every role, practice or process step has to be used. Scrum, in contrast, doesn't provide this flexibility. If a change to the original content is implemented regardless, the APM approach transforms to *Scrum But*.

Despite the offered flexibility, Seibert (2007, 47) criticises the high implementation effort a company with a traditional project management has to endure, especially if the approach is implemented in the whole organisation and not only for certain projects. He moreover claims that this effort is even aggravated, because the applicability of agile approaches has to be tested for different circumstances. In addition, suppliers have to be integrated without an available interface within the process. (ibid.) Whereas DSDM counters this point of criticism with connection points for partners or suppliers, Kanban pursues the goal of reducing the change impact on the organisation's culture. Without new roles and a new process, the employees don't have to change their working style entirely, however, in a way the existing process is made agile and lean. Aside from that, Kanban offers the possibility to integrate stakeholder interactions, for instance, suppliers filling a buffer or activity within in the value stream map.

According to Seibert (ibid.), the resulting "… cultural change …", which all approaches excite, though, with a differing severity, makes it difficult to obtain acceptance of the employees, but also of the administration of a business (Tudor 2010, 70).

3.4 Differentiation from Traditional Project Management

In order to still receive the conviction of the organisation and other involved stakeholders to implement APM, its positive impacts have to be regarded. These become visible, while contrasting the agile with the traditional approach.

This *traditional project management* (Rubin 2012, 29), also described as *classical* (Preußig 2015, 33), differs from the APM in a fundamental way. One of the traditional, plan-driven approaches, the so-called **Waterfall Process**, is shown as a representative in figure 21. Although both the traditional and agile approaches consists of the same phases (ibid.), the Waterfall Process passes them only once, in contrast to APM, which iteratively runs through them.

In comparison to Scrum, DSDM and Kanban, each phase is completed only once by passing a milestone, before the next phase follows subsequently. This procedure requests a detailed plan until the end of the planning phase, listing the requirements the product has to fulfil as well as how it should be developed. Therefore, the project team and the customer have to know up front, which concrete features and characteristics of the product will bring the highest value. (Rubin 2012, 29) Even though the planning in the beginning of the project should facilitate the development of the products, several problems often occur while proceeding with the plans of the Waterfall Process (ibid.). Due to the early planning stage during a project, customers often have difficulties in demarcating the exact scope of the product. Besides, this approach isn't flexible in reacting, for instance, on competition, changing market circumstances or new technologies (Seibert 2007, 41) owing to the early fixation on the product requirements.
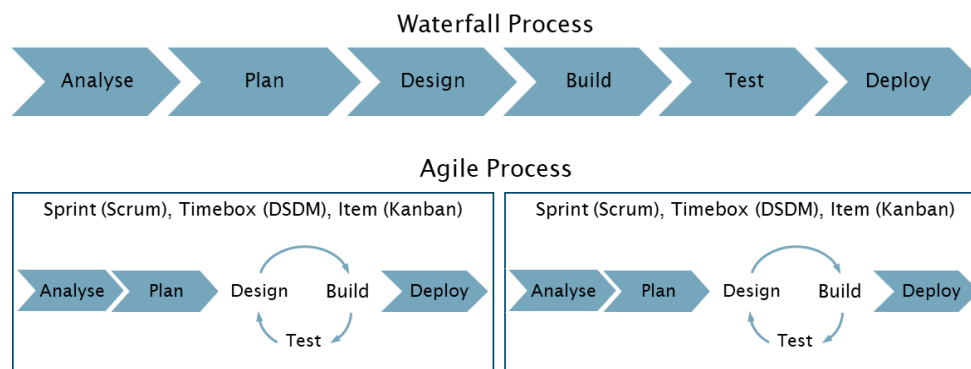

Figure 21. Waterfall Process vs. agile process
(adapted: (Yves Baseke N.d.))

As it can be seen in the following figure, the cost of change increase exponentially by time if change request based on an increased customer's knowledge or as reaction on a market circumstance change occur. Examples are the integration of new requirements or the fixing of existing ones. This exponential increase results from an increasing number of other features or characteristics in an increasing level of maturity, being affected by the change the further the development is advanced. (Rubin 2012, 41).

APM eliminates both problems of an early decision for the product scope and exponentially increasing costs of change. These improvements are reached with the usage of development iterations. Admittedly, also all agile approaches, in especially DSDM, perform a scope planning before the development commences, but it is applied only on a high-level due to APM's expectance of always occurring changes (Seibert 2007, 42). The final decision for an iteration scope is therefore done in the "… latest responsible moment …", and always considers the customer's knowledge and market circumstance at this point of time (Rubin 2012, 37–38). Due to this intermediate customer and market feedback, the need for changes is reduced, on the one hand, and moreover opens the opportunity to implement the remaining change request, when they occur. This leads to a similar low cost of change during the whole project.

	Traditional	Agile
Stakeholder Influence		
Cost of Change		
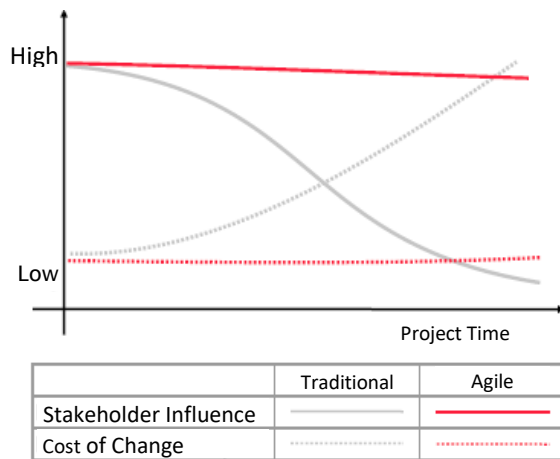
Figure 22. Change during an agile and a traditional project
(adapted: (Preußig 2015, 15))

Another advantage of the iterative and incremental procedure, contrasting traditional project management, is a faster return on investment (ROI). Whereas the traditional approach is able to deploy and sell the final product, when it is entirely completed; agile developed products can be sold in part after each iteration. (ibid., 252) These intermediate increments, additionally, support the creation of an intermediate

customer and user feedback enabling the integration of improvements already during the development. Comparing traditional projects, possible product usage issues are not received until the deployment of the complete product.

These differences between agile and traditional project management request a relocation of the variables in a project. Whereas the time and resources are variable and the scope is fixed in traditional projects; APM, in contrast, fixes the time and resources resulting in a variable scope. DSDM further considers quality as additional, fixed demand. Figure 23 shows the placement of the scope as a variable project demand in an agile project supporting a faster responding to changes (Craddock et al. 2014, 3.3). This triangle transformation offers the base for iterative and incremental development and, additionally, prevents the unplanned increase of the preassigned time and resources, which often occurs in traditional projects. Nonetheless, the variable scope of agile projects can lead to problems, when it comes to contracts between the project team and the customer. Since the project management team can't promise every requirement up front, traditional fixed-price contracts are not suitable. Nevertheless, there are other solutions, like the minimum usable subset, which can form the foundation for a contract; or special agile contract models, which can counter this disadvantage. (Preußig 2015, 39–40)
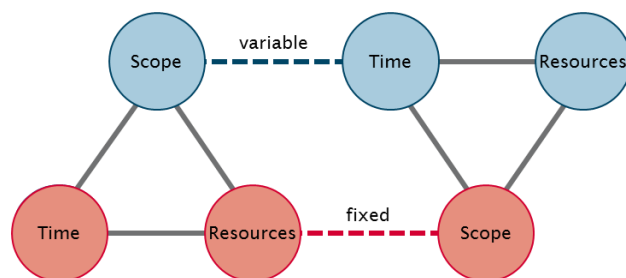

Figure 23. Project variables - agile vs. traditional
(adapted: (Craddock et al. 2014, 3.3))

Whereas the traditional project management can be applied, uncared its efficiency, for each individual purpose, the suitability of an APM approaches has to be examined. This fact also refuses the evaluation and selection of Scrum, DSDM or Kanban as the general best available Agile Project Management approach. Although, optimal conditions for the application of APM are prescribed by several authors (Cockburn 2006, 222; Preußig 2015, 37–38), the big variety of roles, practices and process steps, also within one approach, as well as a lack of a general best practice leads to the necessity of a project individual inquiry and evaluation.

3.5   Internet of Things and Agile Project Management

For verifying a possible usage of agile project management approaches for Internet of Things development project; Scrum's, DSDM's and Kanban's roles, practices and processes are compared to best practices of IoT experts for handling the identified development challenges. Based on this analysis, characteristics for a theoretical agile project management framework are derived.

3.5.1   Alignment of IoT Best Practices and APM Approaches

Regarding table three, which considers the first challenge of an increased number of involved disciplines, similarities can be discovered. Both Song and others as well as Rowland and colleagues recommend the creation of an interdisciplinary team consisting of the necessary perspectives to create an aligned IoT solution.

Whereas Kanban dedicates the consistence of the team to the project's person in charge, Scrum and DSDM are in need of these interdisciplinary teams. Integrated in their development teams, members with the necessary skills are responsible for transforming the technical requirements into the actual solution. DSDM, furthermore, increase the amount of perspectives with different kinds of technical and economic roles. For handling the communication within the teams, all three approaches offer meetings such as daily stand-ups or retrospectives to clarify tasks, decisions and problems. The Dynamic Systems Development Method, additionally, introduces Facilitated Workshops, which are supposed to enable fast results for interdisciplinary team collaborations. Also, Andelfinger and Hänisch suggest meetings in form of interdisciplinary discussions between scientists, producers, users and philosophes in order to clarify questions about the possibilities of IoT applications, but also about their ethical aspects.

Table 3. Challenge 1: An increased number of involved disciplines

IoT Experts	Scrum	DSDM	Kanban
Team			
Extension of the development team with necessary skills (Rowland et al. 2015, 255, 605) (Song et al. 2014, 77)	Interdisciplinary team	Interdisciplinary team	-

Communication			
Interdisciplinary discussions, including scientist, producers, users, philosophes (Andelfinger, Hänisch 2015, 67)	Daily Scrums, Sprint Retrospective	Facilitated Workshops, Retrospective	Daily Stand-up Meeting, After Meeting, Issue Log Review and Escalation, Retrospective

These involved disciplines do not just occur during the development, but also have to collaborate to solve interdependencies. Rowland and colleagues as well as Song and others therefore discuss the usage of methods to provide the management team with a holistic overview of the topic, which the project is investigating.

➢ Due to this alignment of IoT experts' best practices and the agile approaches, a necessity of interdisciplinary teams combining the required skills, can be identified as a requirement of a theoretical IoT project management framework.

➢ Also, a forced communication, which was recommended in varying forms, between these parties has to be considered.

As it can be seen in table four, the IoT experts as well as Scrum and DSDM recommend uses cases based on the solution's user. Rowland and colleagues pursue the goal, not only with written scenarios but also in a graphic version, to describe interactions within and also in between systems. Song and others additionally intents to define requirements by analysing the user's needs, which are also utilised to receive a project budget. Due to this purpose, it can be compared to DSDM's Business Vision, which has to justify the Sponsor's budget. Besides, Rowland and others mention the usefulness of *service ecology maps*, which illustrate activities in different detail levels in the system's context. Although, Scrum's and Kanban's backlogs just as DSDM's PRL are created as a comprehensive list, similarities can be identified, as they are viewing their comprising stories or other requirements with different kinds of detail levels.

Table 4: Challenge 2: An occurrence of interdependencies between the disciplines

IoT Experts	Scrum	DSDM	Kanban
Functions and Requirements			
Story boarding (Rowland et al. 2015, 586)	User Story map	User Story map, Business Vision	-
Use case scenarios (Song et al. 2014, 77)			
Service ecology maps (Rowland et al. 2015, 203)	Product Backlog	Prioritised Requirements List	Backlog and input queue

Collages (ibid., 580)	-	Feasibility Assessment, Foundation Summary	-
Prototypes			
Prototypes, mock ups (McEwen, Cassimally 2014, 64–70; Song et al. 2014, 77)	-	Modelling	-
Video prototypes (Rowland et al. 2015, 580)			
Process			
Elevator pitch as the starting point of design (ibid., 184–185)	-	Business Vision	-
High level architectures of mapped systems split into more controllable components (Song et al. 2014, 77–79)	Sprint Planning, Estimation, Prioritisation, Sprint Backlog	Timebox Plan, Estimation, Prioritisation (MoSCoW)	Queue Replenishment Meetings, Estimation, Prioritisation
Design responses, refinement, evaluation (Rowland et al. 2015, 603-606, 203)	Sprint Execution, Sprint Review	Evolutionary Development, DSDM Timebox (investigation, refinement, consolidation)	Development, Triage, Issue Log Review and Escalation
Integration, validation, deployment, configuration, delivery, training (Song et al. 2014, 77–79)	Deployment	Deployment Phase, Post-Project Phase	Deployment
Minimum viable product (Rowland et al. 2015, 238–239)	-	Minimum usable subset	-
Minimum functions working in case of failure (McEwen, Cassimally 2014, 36–37)			
Testing			
Use case tests based on the customer journey (Baumgartner, Mlynarski 2017)	Tests based on acceptance and quality characteristics	Tests based on acceptance and quality characteristics, for timebox and increment	-
Tests on split components (Song et al. 2014, 79)			

Next to collages, which have the same surveying function as the Feasibility Assessment and the Foundation Summary, prototyping plays an important role for DSDM as well as for the IoT specialists. Models in varying forms enable, according to both, a fast problem identification in the system's context as well as a facilitation of the communication being able to attach people to the project or receive a funding. McEwen and Cassimally (2014, 64) describe prototypes, moreover, as development process initiators. Rowland and others, in contrast, recommend *elevator pitches*. Comparable

to the Business Vision, they describe the product vision in terms of purpose, functions, and usefulness in a short, certain amount of time.

The best practices show further similarities such as the subdivision of requirements into smaller components, likewise the Sprint or the Timebox Planning as well as the Queue Replenishment Meetings. Next to the refinement of design, which is comparable to the iteration reviews, also contrasts can be identified. Admittedly, the experts recommend the usage of a minimum viable product as a base for the software development, which is also a part of DSDM, but neither mentions the need or a procedure for an estimation or a prioritisation. Finalising Scrum's and Kanban's process with the release of the increment or final product for deployment, DSDM likewise Song and colleagues share the need for after-deployment activities, like configuration, delivery or training.

Also, testing activities are important for IoT development due to otherwise occurring security issues or functionality failures. Baumgartner and Mlynarski, e.g., recommend the usage of test cases based on the usage flow describing *customer journey*, which is comparable to User Stories. Song and others describe the opportunity of testing the products based on specific criteria, which are linked to the requirements, and therefore endorses the test procedures of Scrum and DSDM.

➢ Further features for a theoretical framework, which fulfil the second challenge, can be deduced. Before developing the actual solution, an overview becomes necessary to recognize the product's whole scope.

➢ The facilitation through models is considered as efficient and facilitating, and can be implemented in the theoretical framework.

➢ Only based on both, every interdependency can be identified, which becomes necessary for aligning each task of the development process and each component of the whole scope after its deployment.

The increased complexity, which is designated as the third challenge, can be, according to the experts, reduced by the creation of a testing strategy (Baumgartner, Mlynarski 2017) as well as the breakdown of requirements. Mentioned in table five, it can be moreover handled with an iterative development approach. Whereas Rowland and others share commonalities with the APM approaches by demanding a general iterative approach of "… design, development and evaluation …", McEwen and

Cassimally choose a different iterative idea. In contrast to APM's pre-defined itera-
tions, they assume the necessity of an iteration if a problem was found as a best
practice. In addition, a parallel development of the three IoT components is sug-
gested, however, considering the hardware and the software independently in the
beginning. Regarding Scrum in this context, the development strategy is up to the de-
velopment team. Kanban pre-defines it with the order of general activities and Card-
dependent procedures. Defined in the Development Approach Definition, DSDM's
development team can approach it either likewise the IoT expert's suggestion, or by
completing the development of one component first, before starting another.

Table 5. Challenge 3: An increased complexity

(IoT) Experts	Scrum	DSDM	Kanban
Iterations			
Iterating the design after a prob-lem was found (McEwen, Cas-simally 2014, 64–65)	Pre-planned Sprints based on Sprint Backlog	Pre-planned Timeboxes based on Timebox Plan	Iterations based on activities and WIP limit
Iterative phase of design, develop-ment and evaluation (Rowland et al. 2015, 203)	Sprint Planning, Sprint Execution, Sprint Review	Timebox Plan, Timebox, Timebox Review Record	Queue Replenish-ment Meeting, Development, Re-lease Planning Meeting
Developing three things parallel: the physical objects, the electron-ics, and the software (McEwen, Cassimally 2014, 64)	Development Team develops autonomously	Development Ap-proach Definition	Development de-pending on order of activities, card-develop-ment procedure
Initially focus on software and hardware separately (ibid., 65)			
Documentation			
Necessity for an increased docu-mentation for use case develop-ment (Bednarczyk, Queins 2013)	User Stories	User Stories, products	Cards (kanban)

The complexity of IoT projects is not only a challenge during the project, but also in
hindsight. Bednarczyk and Queins, who are experts for requirement documentation,
claim that development projects utilising use cases, which are recommend by IoT ex-
perts and used for APM approaches, disregard the project documentation. Due to
the often-exclusive existence of User Story cards, new employees have problems to
understand the product's structure due to its complexity. In addition, it is difficult
and inefficient for project teams, which further develop an existing product, to start

without a detailed structure overview. Consequently, reverse engineering becomes necessary. Whereas Scrum and Kanban offer User Story cards solely, DSDM provides a range of documentation products such as the Timebox Review Record, the Solution Architecture Definition and the Management Approach Definition. Thus, DSDM is able to prevent problems which is caused by insufficient documentation.

➢ Deriving from both the experts' best practices and APM's solutions, iterations are the essential component of the project management approach. Pursuing the goal of being agile, they can't just be implemented, when a problem occurs, but have to be pre-set to enable a fast responding. In consideration of the requirements of IoT development projects, they have to be considered for all four components of IoT solutions. Since APM wasn't created to cope with differing components, their alignment has to be examined during the actual development. Therefore, the experts' opinion of treating them separately is considered as an approach.

➢ As an extensive documentation in neglected in one of Agile Manifesto's values, a theoretically best documentation scope can't be identified. Likewise DSDM suggests, its scale has to be therefore examined for each project separately. Nevertheless, it shouldn't be too extensive to prevent the teams of being agile.

Regarding the methods for handling the last challenge of a development focuses on involved users or systems, which is described in table six, the creation of requirements from the user's perspective is commonly mentioned. Whereas Scrum, DSDM and Kanban use User Stories and Persona moving the user into the focus, which is backed by Rowland and colleagues in from of *user portraits* or a *customer journey map;* also, co-design workshops are introduced as a possible method. Comparable to DSDM's Facilitated Workshop, they have the goal to create new ideas in cooperation with the development team and a directly involved user. Also, the observation of user interactions in the planned product environment, so-called *field visits*, is described as another efficient opportunity to identify users' problems and needs. Creating user feedback based on prototype-user interactions to review the identified needs; helps, according to McEwen and Cassimally, to adapt the product requirements to changes caused, for instance, by differing user needs or identified interaction problems. Also, Scrum and DSDM's increment reviews, or Kanban's Triage pursue this goal.

Table 6. Challenge 4: A development focused on involved users or systems

IoT Experts	Scrum	DSDM	Kanban
Need identification			
User co-design workshops (Rowland et al. 2015, 181) User story timelines (ibid., 172–174) Field visits (ibid., 176–177) User portraits, Persona (ibid., 189–191) Customer journey map (ibid., 193–194)	User Stories, Persona	User Stories, Persona, Facilitated Work-shops	User Stories, Persona
Review			
Review of prototype with people to find out how they interact with it (McEwen, Cassimally 2014, 151)	Sprint Review, increments	Timebox Review, increments	Triage, increments

Summarising the comparison between IoT experts' recommendations of how to develop an IoT product and Scrum's, DSDM's as well as Kanban's agile way of developing, essential similarities can be identified. Both have noticed the necessity for an overview of the whole system in the beginning of a project, being able to estimate the impact of the project regarding the necessary resources in form of skills or perspectives as well as a budget. In addition, aligned requirements can be created based on the structure overview and a product vision from the user perspective, being reviewed and verified with test strategies and models. Furthermore, an iterative way of developing, which is embedded in a defined development process, is described as necessary to respond to occurring changes which commonly originate, e.g., from reviews or system interdependencies.

➢ Summarising, the user is in the centre of both parties. Whereas each the specialists and Scrum, DSDM and Kanban recommend Persona and differing kinds of User Stories to provide user-centricity, they can be set as characteristics for defining requirements in the theoretical framework.

➢ Besides, reviews with the users or other involved parties are essential to initiate feedback about the idea and create a solution; both enabling fast changes.

3.5.2 Conclusion & Verification of the Research Key Assumption

The consolidation of the identified characteristics of a theoretical framework is illustrated in figure 24. As it can be seen, the user is the foundation of the entire approach by either being integrated into the team or connected indirectly. The latter possibility is pictured through the dotted line surrounding the team's members. The team itself consists of the necessary disciplines, which should communicate actively and continuously throughout the complete project. After a need or an idea is identified, the creation of Persona and User Stories leads to the mapping of the comprehensive project scope. It is supported and facilitated by models of any kind. On this foundation, tasks for each of the Internet of Things components, which were derived as: hardware (H), software (S), electronics (E) and service (S*); are broken down and iteratively developed. Afterwards, they are tested separately. In case of a positive test outcome, the increment (I) or completed product is considered as a whole during the deployment building a minimum usable subset, before another iteration continuous or the project is closed.

Contrasting the research's key assumption to its outcome, agile project management can be verified as a possible theoretical foundation for a project management framework, which is able to manage IoT innovations. During the analysation of agile values and principles, roles, practices as well as the process, a common foundation was identified, which is able to fulfil IoT development's requirements as well as accomplishing its challenges.
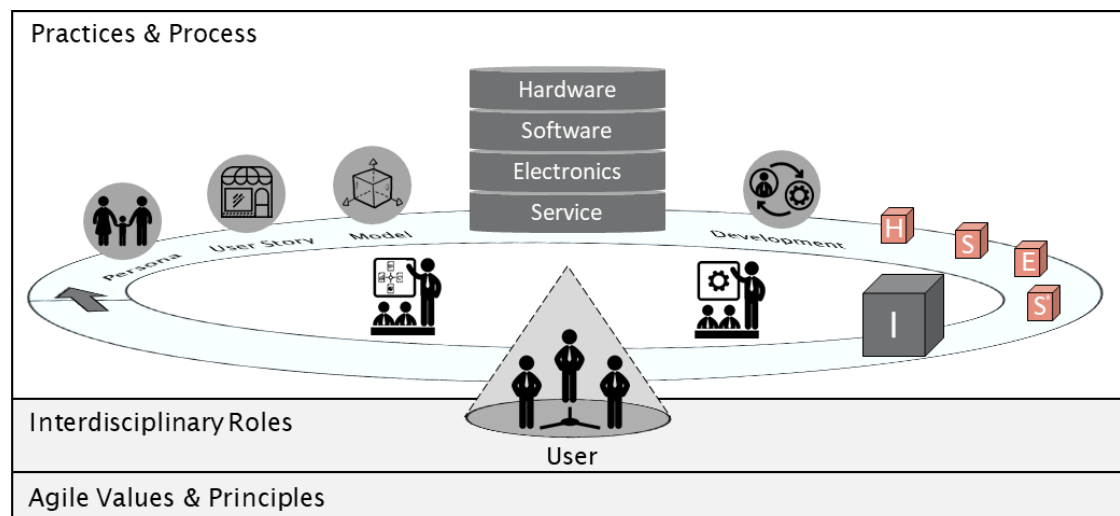

Figure 24. Theoretical agile project management framework

Also, IoT experts' research lead to best practices, which show common characteristics to extracts of each of the three agile project management approaches. A single best APM approach wasn't, however, identified. This is also reasoned by the necessity for the framework to consider the existing circumstances of the project's host company and its environment for the framework's implementation into a certain organisation. Nevertheless, initiated from this foundation, fitting agile practices were identified which can facilitate the conversion from an idea into a deployed product. To find the fitting ones, the framework has to be applied to a real pilot project being able to confirm agile project management as the right foundation for Internet of Things development projects.

4   ITAB Shop Concept Finland Oy

Since all three APM approaches: Scrum, the Dynamic Systems Development Method and Kanban; respond to IoT's challenges in differing ways, the best fitting roles, practices and processes have to be identified for the application to an actual development project. As a foundation for the evaluation of these artefacts and their alignment with the host company, the project's circumstances have to be illustrated and analysed.

4.1   Company Overview

Hereafter, *ITAB Shop Concept Finland Oy* will be referred to as *ITAB SCF*

The host for the framework's actual development project was *ITAB Shop Concept Finland Oy*. It was founded under the name *Pikval Oy* in the 1950s as Finland's first firm developing metal shop fittings. Between 1970 and 2005, it was part of *GWS AB*, which also developed and produces metal shop fitting. Following a short period of independence, a Finnish venture capitalist funded *Pikval*, before it was acquired by the Swedish concern *ITAB Group* in 2016. Integrated into *ITAB Shop Concept AB*, by changing the name from *Pikval Oy* into *ITAB Shop Concept Finland Oy,* the company's new purpose was the representation of the north-east section of Europe. The figure 25 shows that next to the parent company *ITAB (Shop) Concept*, there are moreover the sub companies *Nordic Light*, *ITAB Products* and *ITAB Pharmacy*, which in detail consist of several regional subsidiaries that represent certain areas in Europe as well as Asia. (ITAB Shop Concept AB (Ed.) 2017b)
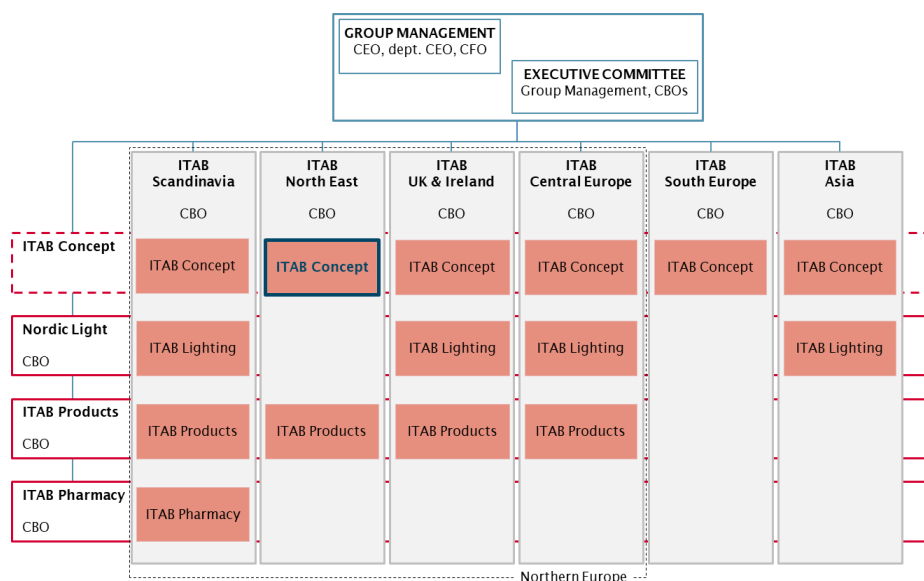

Figure 25. *ITAB Group* organigram/company structure

Originating from a tube manufacturer, which was founded in the 1970s, the *ITAB Group* has a history of organic, but also of growth by acquisitions. Compromising 21 production facilities in 15 countries, the group with its headquarters in Jönköping, Sweden, offers complete store concepts consisting of products such as checkouts systems, lightning systems and basic shop fittings for the retail industry. (ITAB Shop Concept AB 2017a, 5–9, 17) Next to the production of these existing products and the offering of installation services, its development focuses on new solutions such as automated self-checkout solutions (*ITAB EasyFlow*) or stores without cashiers (*ITAB AirFlow*). Lead by the management team, which is represented by the CEO Ulf Rostedt, the *ITAB Group* reached a turnover of approximately 565.77 million euros (SEK 5.417 million, with an exchange rate of EUR 1 = SEK 9.5746 (finanzen.net (Ed.) 2017)) and a profit after tax of 260 million euros in the year 2016. Compared to 2015, the turnover was increased by four per cent; whereas the profit after tax declined by four per cent, or 24% respectively, taking previous year's restructuring costs into consideration. At the end of the last fiscal year, the number of employees in the *ITAB Group* amounts to 3097. (ITAB Shop Concept AB 2017a, 5–9)
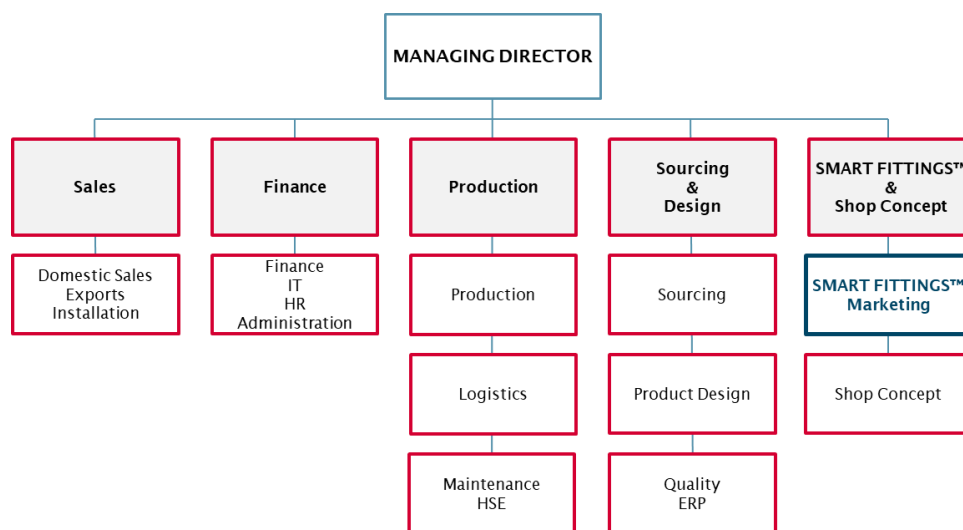

Figure 26. *ITAB Shop Concept Finland Oy* organigram

Being part of *ITAB's* key business driver "Creating the ultimate shopping experience, close to you." (ibid., 14), *ITAB Shop Concept Finland* contributed a turnover of 28 million euros to the comprehensive outcome. After a sales decrease between 2014 and 2015 (19 to 17 million euros) and an increase to 28 million euros caused by the integration into the existing *ITAB Shop Concept Finland* in 2016; the turnover for 2017 is prospected to be 27.5 million euros (ITAB Shop Concept AB 2017a, 7; Pikval (Ed.) N.d.)

Currently, 120 employees are working for the organisation (see figure 26) in its head-quarters and production facility in Vaajakoski and office facility in Vantaa. Under the command of managing director Kalevi Koistinen, *ITAB SCF* is maintaining its high market share, in especially in Finland, with the development, production and installation of modular metal and wood shop fittings, but also with services, like support and maintenance or conceptual store design. Next to the traditional, hardware shop fittings, also digital ones are developed. It is handled within the SMART FITTINGS™ & Marketing department, which replaced the former product management and offering. Functioning as the host department for the scientific project, it is highlighted in figure 26. Next to the finance department, also consting of the administration, the human resources and the IT department, and the production; the sales department is subdivided into domestic product sales, the product export and the service sales. Under the command of the sales director Salla Gantsi; Finland, Russia and the Baltic countries are served directly. In contrast to *Pikval's* independency, Sweden and Norway are now approached by the *ITAB Group's* other, local subsidiaries.

4.1.1 Customer & Market Situation

The range of retail customers in these countries goes from grocery chains via hardware and sports goods stores through apparel stores. Among others, next to the department store chain *Stockmann* and the apparel chain *Halonen*; the biggest customers in Finland — as *ITAB SCF*'s main market — are the residential *K Group* (*Kesko Corporation*) (Kesko Corporation (Ed.) 2017b) and *S Group (S Group (Ed.) N.d.)*. Both are conglomerates, which compromise super- and hypermarkets as well as administering department stores. *Kesko*, furthermore, runs hardware and sports goods stores. In 2016, both companies had an aggregated market share of approximately 85% in the Finnish grocery market (Kesko Corporation (Ed.) 2017a).

With the first grocery turnover decrease (by -0.7%) in Finland since the global financial crisis showed its impacts in 2009 and 2010; a total amount of 16.424 billion euros was generated. Besides, the Finnish clothing as well as footwear sales declined by 5.5%, or 0.8% respectively. (Finnish Grocery Trade Association (PTY) (Ed.) 2016; Kotakorpi 2015) With an aggregated turnover reduction of 1.5% in 2015, Finland showed the highest decrease in the EU-28 states and was next to Cyprus and Greece

the only country with a negative growth (Lichtner 2016). Whereas the *GfK Retail & Real Estate Consulting* forecasted similar figures for 2016 (ibid.), more recent statistics (Official Statistics of Finland (OSF) 2016) show that the retail sales were increased by 0.7%. The actual figures for 2017 confirm this growth trend (Official Statistics of Finland (OSF) 2017). Nonetheless, Finland's retail finds itself in difficult times. Retail, as the biggest employer in a country with 5.2 million inhabitants (van Bocxlaer 2017), has to prepare itself for already ongoing and upcoming changes. Already in 2015 showing its impact in the clothing (+14%) and footwear sector (+33%); the growth of online stores lead to turnover reductions for local, but also foreign chains, like *Lindex* or *Zara*. Only sports goods chains were able to present a positive growth in both sectors. (Finnish Grocery Trade Association (PTY) (Ed.) 2016)

Hence, this sales shift leads to consequences for the related shop fitting industry. The amount of grocery stores in Finland has declined from ca. 10,000 in the 1990s to approximately 3,100 in 2015. Admittedly, the reduction speed could be slowed down, but is since 2008 steadily ongoing. (Finnish Grocery Trade Association (PTY) (Ed.) 2016; Kotakorpi 2015) Even though the high growth of online stores will increase the e-commerce market share from 5–10% (Hamilton 2017; Simon 2017) in 2017 to 25% in 2025, which was forecasted by *Bain & Company* (Paton 2017), the importance of brick-and-mortar stores will still remain. According to members of a German shop fittings association, architecture offices and clothing companies; the focus of "offline" stores is, however, going to change.

Being able to respond to customers' changing preferences, stores will no longer focus on the product selling, but on shopping as an experience. (Henkel 2017; Paton 2017; Simon 2017) Already existing examples are retail areas with additional services, like climbing parks or phone repair offers. Besides, stores were launched, e.g., by *Samsung*, which focuses on the brand and product experience without the intention to sell. The American consultancy *Shop! USA* designates this shift as the change from the point of sale (POS) to the point of engagement (POE). (Henkel 2017) Next to further retail trends like pop-up stores (Henkel 2017; Kalscheur 2016), also the digital transformation encourages this change. Mentioned are, for instance, the usage of augmented or virtual reality making it able to expedite the seamless experience between the brand and its sales channel portfolio. (Henkel 2017; Paton 2017)

Next to consultant and researcher Manfred Spitzer who examined German shop fitting organisations; moreover, Jonathan Chippindale, the CEO of an augmented reality solution provider, still sees a general problem in the implementation of digital solution to fulfil a seamless shopping experience. That is why he describes a retailers' "… holy grail …" as the creation of a "… digital empathy …" being able to offer the right mixture between the digital world and the offline experience. (Paton 2017)

4.1.2   Development Department and Product Line SMART FITTINGS™

In 2015, *ITAB SCF*, still being *Pikval Oy*, recognized this transformation and consequently founded the development department SMART FITTINGS™. With the vision of digitalising the wood and metal shop fittings portfolio, a new product line was created. Initiated with digital signage solutions (see figure 27), further projects lead to the integration of intelligence into the "analogue" fittings. As illustrated in figure 27, an exemplary product is the *DS Connecting Shelf*. It is able, due to the integration of sensors, to detect which product was chosen by the customer to subsequently display additional information such as special offers or complimentary products on the digital signage. This solution's intention is an improved shopping flow for the customer as well as an increased value of the customer's shopping basket leading to a growing store turnover.
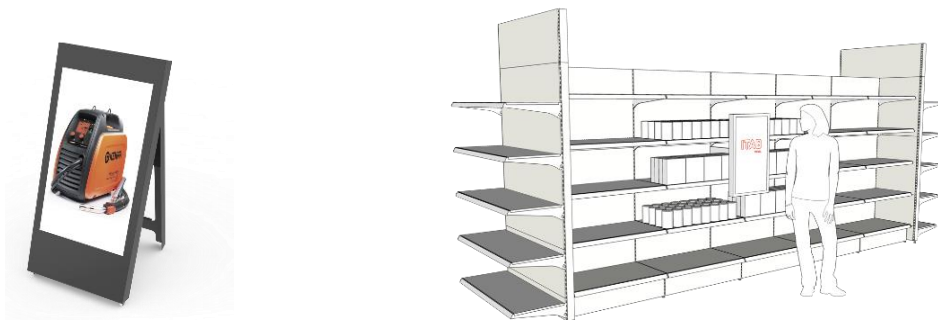

Figure 27. Digital signage products: DS A-teline 32" (ITAB Shop Concept Finland Oy (Ed.) 2016) (left), DS Connecting Shelf (Nousiainen 2017) (right)

A different product is the *Smart Shelf* (see figure 29), which can detect if and when a product, e.g., a can or bottle is removed from a shelf. As a result of the created data, the shop staff and the brands are able to recognize when the shelf has to be refilled and how to calculate the delivery man's refill route between several shops. This added value, which can be also created by the *DS Connecting Shelf*, shows that SMART FITTINGS™ products aren't just an extension of the product line, but also

have the goal to create, collect and provide to the internally so-called *actionable data*. This new business field is predicted to have a big potential for *ITAB SCF*.

Both described products and other digital signage solutions are connected to the Internet via Ethernet or a wireless connection, and provide a web-based application for the content and data management. Shop owners and brands have access being able to integrate, for instance, offers, pictures and videos which are displayed after being triggered based on a schedule or sensors. In addition, they get access to a data dashboard illustrating the product's real-time information and statistics. As a result, each SMART FITTINGS™ product, except the *Smart Aroma* product as an ubiquitous aroma evaporator, can be designated as Internet of Things device.

Note

The following part can't be published owing to confidentiality restrictions. In case of a further interest in this thesis, please contact ITAB Shop Concept Finland Oy (petri.kallberg@itab.com) and the author (philipp.schwan@gmx.net).

5   Constitution of an Agile Project Management Framework

6   **Framework Implementation**

6.1   SMART FITTINGS™ Development Project

6.1.1   Pre-Project Phase

6.1.2   Feasibility Phase

6.1.3   Foundation Phase

6.1.4   Foundation Phase II (Revival)

6.1.5   Evolutionary Development

7   **Concluding Remarks**

7.1   Retrospective & Benefit Assessment

7.2   Conclusion

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Appendices

Appendix 1: A.1 Internet Architecture & HTTP vs. MQTT
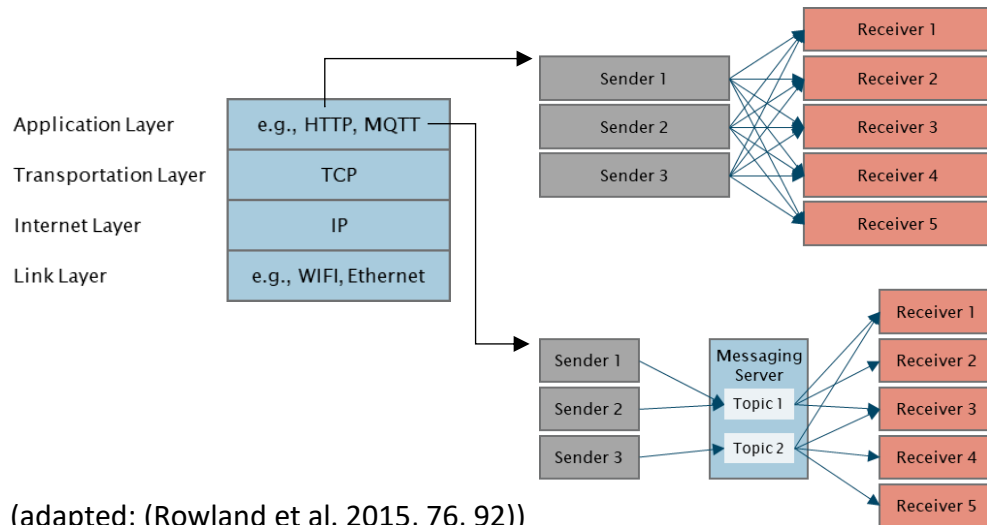
(adapted: (Rowland et al. 2015, 76, 92))

Appendix 2: A.2 Agile Practices

A.2.1 Pig and Chicken Story

(Vizdos 2006)

A.2.2 Fibonacci Cards

The Fibonacci row: ½ to 100; represent the evaluation outcome. Whereas the *0*, which pictured as a card in the following figure, designates the requirement is too small, the ∞ describes it as too big to evaluate. The question mark leads to a required rehearsal of the requirement explanation. As last card, the coffee cup shows that a break during the Planning Poker is requested. (Preußig 2015, 100)
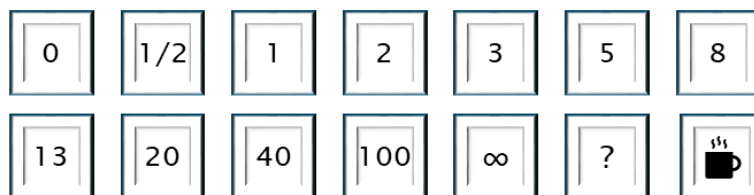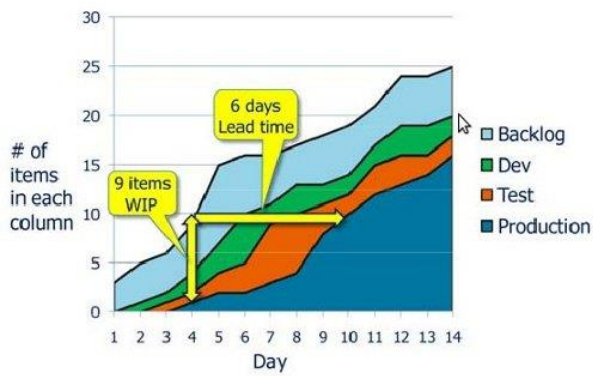

(adapted: (ibid.))

A.2.3 Burndown chart – Example
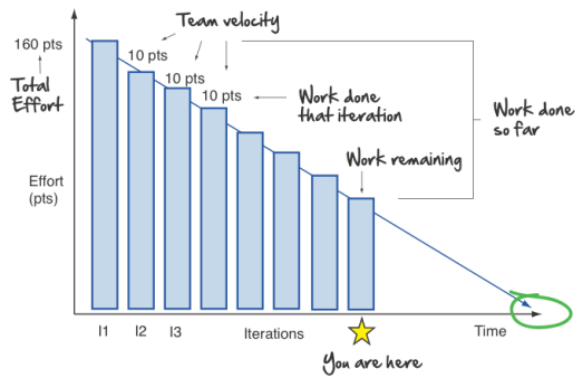
(Rasmusson 2014)

A.2.4 Cumulative Flow Diagram – Example

(Ronen-Harel 2013)

Appendix 3: A.3 Workshop: Actual State Analysis

A.3.1 SMART FITTINGS™ Product Innovation Process – VCD

A.3.2 SMART FITTINGS™ Product Innovation Process – EPC

Appendix 4: A.4 Interviews

A.4.1 Interview No. 1

A.4.2 Interview No. 2

A.4.3 Interview No. 3

A.4.4 Interview No. 4

A.4.5 Interview No. 5

A.4.6 Interview No. 6

A.4.7 Interview No. 7

Appendix 5: A.5 Role Allocation with the GMIAC Matrix

Appendix 6: A.6 Facilitated Workshop

A.6.1 Scope Extension

A.6.2 List of Usage Areas, Functional and Non-functional Requirements

Appendix 7: A.7 Permission for Publishing of the DSDM Consortium

Von: Kim Whitmore <kim@agilebusiness.org>
Datum: 9. Mai 2017 um 16:46:27 OESZ
An: "Philipp.Schwan@stud.hs-esslingen.de" <Philipp.Schwan@stud.hs-esslingen.de>
Betreff: FW: Usage of DSDM in my bachelor thesis

Dear Philipp

Thank you for your email and we are delighted you are using DSDM in your thesis

As long as the proper citations are used we are happy to give our permission for you to use the material.

Good luck with your studies.

With kind regards

Kim Whitmore
Executive Assistant
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Declaration of Academic Honesty

I hereby declare that the thesis submitted is my own unaided work. All direct or indirect sources used are acknowledged as references.
This paper was not previously presented to another examination board and has not been published. I am aware that untrue declaration will have legal consequences.

Nordheim, 14th August 2017   ....P.Schwan..............

                                                                              Philipp Schwan