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Saxion University

Droneland

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Abstract

In this scientific work, the possibilities and problems of a Droneland were investigated. The three basic parameters of this academic problem solution are, besides the examination of economic efficiency and constructability, the demand (desirability). The latter is divided into the satisfaction of a need and the acceptance of the new technology. The question of acceptance is an integral part of this work.

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1 Introduction

1.1 Main Task

By definition, a drone is an unmanned aerial vehicle or underwater vehicle that is either remotely controlled by humans or controlled by an integrated or outsourced computer, thus becoming (partially) autonomous.[1] At the moment drones are already in use for assignments like taking air samples[2], or to rescue humans in the battlefield.[3] So one of the main questions in this assignment is to explain, why the drones are not already use in other occupation & fields. Also, a part of the task is to create the ideal drone, that means which feature is necessary for drones in a Droneland. Droneland on the other hand means a basically a world where drones have a big impact of humans and their environment. The infrastructure is also very important in order to accomplish with the tasks.

This project was carried out as part of the Summer School IP Vision 2018 in Holland. Before the project was announced, all students took a personality test (DISC, see appendix).

1.2 Vision

Our vision is to create a drone world, where humans and drone can coexist. The drone will become then an integral part of daily life. They will take most of the occupations and will make life on this earth more efficient and less dangerous, for instance nearly 40% of all accidents at the workplace in Germany in 2016 are caused by working on high places.[4]

After the brainstorming for ideas for segment of the drones the group clustered the suggestions in three section. The first section desires ideas that we can already realize, the second section is for ideas that probably will be happening in 30 years and the last section is for ideas that will take more than 50 years to realize.

[1] (Bendel, 2015)
[2] (Scentroid, 2018)
[3] (Condé Nast Verlag GmbH, 2018)
[4] (Deutsche Gesetzliche Unfallversicherung e.V. (DGUV), 2016) Page 10

2 Generate of Ideas & Problem Analysis

The goal was to create ideas and to figure out the problems.

2.1 Generate Ideas (State – Gate – Model)

The first two steps of the state gate model were used to generate ideas. In the first step, the ideas were generated by use of brainstorming. After that it was divided into three groups. In the first group are that can be realized in the immediate future. The second contains ideas and suggestions that can only be realized in 20 to 30 years according to the current state of knowledge. In the third and last group are all ideas that can probably only be realized after more than 50 years.[5]

2.1.1 Ideas for use of Drones within the next 5 years

Idea	Description
Development Aid	Use the drone in poor areas like in Africa without infrastructure to send important medicine or blood.
Hospital	Drones do the delivery of important medicine / blood or organs to the destination of a chosen hospital
Fire brigade	Use the drone to find people with an infrared camera after a disaster like forest burn, flood or after an avalanche of snow. 1. Mountain recovery → to rescue an injured person or to send him necessary aid to survive. Able to reach difficult & inhuman areas. 2. Can put out a small fire in a hard-to-reach area to prevent major damage. 3. A drone can send parachutes to people trapped in a tall building.

Table 1: Ideas for use of Drones within the next 5 years

[5] (Stage-Gate Internationa, 2018)

2.1.2 Ideas for use of Drones within the next 5 to 10 years

Idea	Description
Agriculture	Substitute for the shrinkage of bees. Drones take over the task of pollination. Drones can spray pesticides on fruit trees. Drones can take over harvesting e.g. selection of grapes.
Industry	Drones can carry out dangerous work activities, especially those that must be carried out at a high altitude. Drone can carry heavy load (100kg) e.g. roof work Drones can clean windows of big buildings. Drones can carry out work on a wind turbine or high-voltage conductors.
Service Industry	Post office → Important delivery (priority) Drone banner adverting
Police	Drone can pursuit criminals Police can find easier criminals in a crowd
Environment Protection	Can film endangered animals for studies without hurting them and can make important research to safe the species, e.g. Java Rhino.

Table 2: Ideas for use of Drones within the next 5 to 10 years

2.1.3 Ideas for use of Drones in 25 - 50 years

Idea	Description
Ocean	Drones can free the ocean from plastic waste, while the drones supply themselves with solar energy. No human control is necessary anymore, everything is self-sufficient.
Energy Production	Several drones in the universe bundle the solar energy that is not directed at the earth into a laser. The laser is sent to earth and used as a new energy source.
Noise avoidance	The drones can move completely noiselessly through the air and strive for a value of 0 decibels in order not to disturb people and the environment
Invisibility	Drones are not visible to humans' eyes. A technology that is currently being developed by the American military is being used. Metamaterials are used, and the electromagnetic waves are diverted.[6]

Table 3: Ideas for use of Drones in 25 - 50 years

[6] (FOCUS Online Group GmbH, 2015)

2.2 Innovation Process

One of the main questions of the assignment was, why drones are not already a part of our daily life. For solving this problem and to answer this question, it is important to look on the innovation process. This process will show, what is necessary for an invention to become to an innovation.

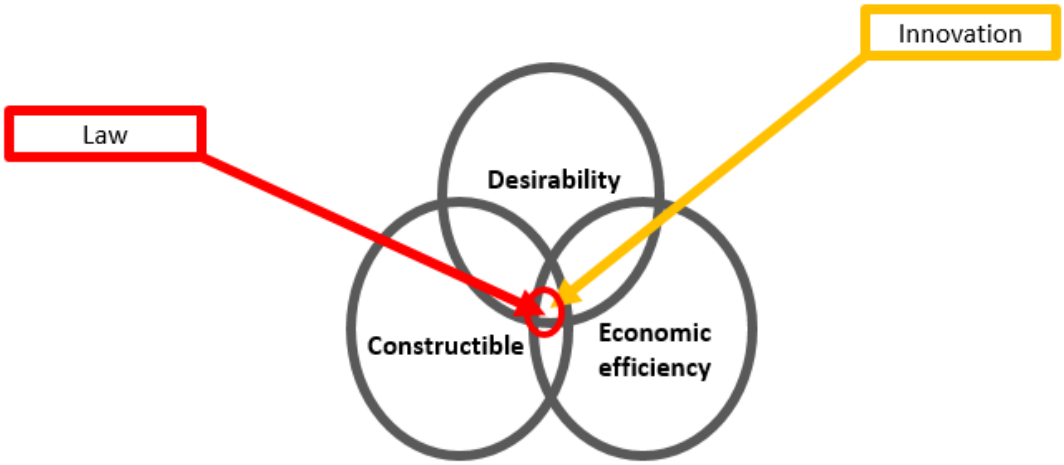

Figure 1: Conflicting issues of Innovation according to Gürtler & Meyer[7]

An invention can only become an innovation, if it is possible to construct it, this includes the product itself and the infrastructure, in this case it would be the parking and charging system and also the new traffic rules. Another point is that the product must have a desirability for the potential customer, it must be satisfied for certain need with a completely new technology that is disruptive, and people have to accept the new technology. The last requirement, that let an invention becomes an innovation, is that the Idea is economic efficient, otherwise it would not be diffused in the market.[8, 9, 10]

[7] (Gürtler, 2014) Page 84
[8] (Hildebrandt, 2017)
[9] (Becker, 2008) Page 221
[10] (Gürtler, 2014) Page 11 - 13

2.2.1 Desirable

The desirability of a new technology is as follows. On one hand, this invention solves a technical problem with a completely new method. On the other hand, the technique has to be accepted by the public.[11] As already mentioned in the previous chapter, there are enough possibilities to use the drone effectively in different areas. The problem why that the drone has not yet established itself in our world is that the population does not accept this new technology yet.

To solve this problem, the advantages are weighed up against the disadvantages, as in technology acceptance research. Acceptance is also a result of social and economic processes during which various influencing factors develop over time. The focus is mainly on the end user.[12]

2.2.1.1 Mindmap - Determination of causes for non-acceptance

Brainstorming with a mind map were done to find some good ideas for the drone land project. The groups task was to find all things that humans don't like about drones and what's holding back the drones to live along humans.

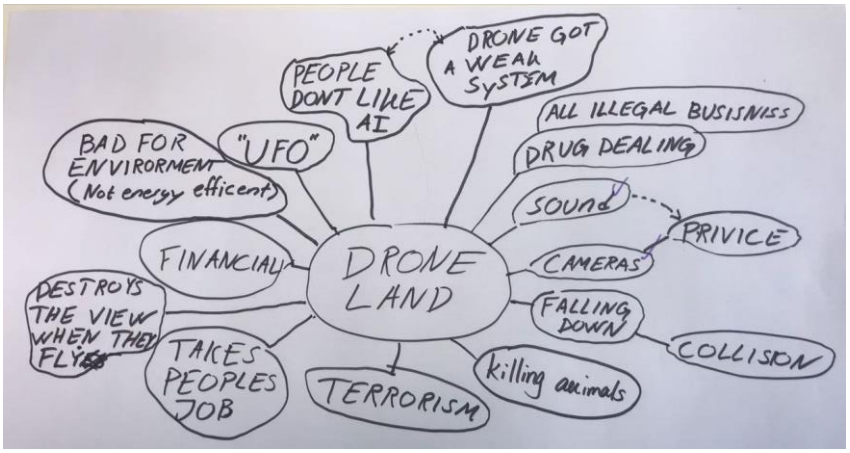

Figure 2: Mindmap - Determination of causes for non-acceptance

After the group had brainstormed with the mind map, it was decided to split into two groups. First group tried to answer all questions that came up while brainstorming. The

[11] (Gürtler, 2014) Page 20
[12] (IZT - Institut für Zukunftsstudien und Technologiebewertung gemeinnützige GmbH, 2016)

second group started with an FMEA with all functions and the possible failures of these functions.[13]

2.2.1.2 FMEA - Prioritization of causes

The FMEA were used for finding every possible problem that could happen in a future drone world. The table is divided by a **Function** column that is the main task of the drones or necessary functions for the drone. After the **Possible Failures** will explain short failures that can happen with that specific function. In the third column **Failure Cause** is shortly explained with a possible outcome. This is followed up with **Worst Outcome** that shortly describes the worst possible error that could happen.

Risk Scale

Every possible failure was ranked 1-5 points in three categories were 5 is the worst outcome and 1 have no impact at all. The three categories are:

- **Probability (P)** where the group must rate the possibility to happen.
- **Severity (S)** here it was ranked the worst outcome and priorities it if the points are 4 or 5 (gives an alert of a red dot).
- **Detection (D)** is the possibility that you find the failure before it will happen.
- **Risk Priority Number (RPN)** it's the result of the FMEA (the product of P,S and D) and the score that will have the highest score will be the most priorities.[14]

[13] (Krengel, 2013)
[14] (Vieregge, 2009)

Detail/Operation					Risk Scale (1-5)				Recomended Solution
Nr	Function	Possible Failures	Failure Cause	Worst Outcome	P	S	D	RPN	
1	Communication	Crash	wrong signal	Fatal outcome	2	5	4	40	Yearly inspections / emergency parachute
		Colision	wrong signal	Fatal outcome	2	5	4	40	Yearly inspections / emergency parachute
		Lost controll of drone	Hacking	Losing drone with goods	2	4	5	40	Identifications of drones. Integrated alarm system.
2	Flying	Crash	Bad weather	Fatal outcome	1	5	2	10	Bad weather restrictions
		Colision	Same altitude	Fatal outcome	2	5	5	50	diffrent altitude for diffrent directions like one hight for North and another for South / emergency parachute
		Birds/animals	Same altitude	Fatal outcome	1	5	3	15	Yearly inspections / emergency parachute
3	Transportations	Losing the goods	Bad securing of the goods	Fatal outcome	2	5	2	20	Lisence for packing goods
		Breaking the goods	Bad stability in the air/landing	Breaking the goods	1	2	3	6	
		Wrong destination	GPS error	Getting lost	1	2	4	8	Registered in a data base
		Wrong destination	Wrong adress	Getting lost	4	2	3	24	
4	Battery	Empty	Bad managament	Fatal outcome	2	5	2	20	
		Empty	Battery failure	Fatal outcome	1	5	4	20	
5	Recharging	Time waste	slow charging process	Late dellivery (money lost)	4	3	3	36	Have a standardization of the battery so the drone can change batteri in the parkingslots.
6	Storage	No space for parking	Drones cant land	Emergency landing	3	3	4	36	Request system before take off
		Stolen	Bad security	lost of the drone	4	2	3	24	Locked parking space for all drones

Figure 3: FMEA for Drone functions

2.2.2 Constructability

The constructability is split in to two parts. In the first part, the ideal drone was created. Then the problem of infrastructure was solved. This can be roughly divided into construction and traffic system.

2.2.2.1 Ideal Drone

The ideal drone in the future needs to make a small noise as possible. This may be possible with a sound that cancel out the sound from the drone and a more energy efficient drone will have a lower noise. The drones in the future need to have an ID-number to prevent illegal uses. One solution could be to have a communication system for drones. Every drone that is in the air can ask for identification of other drones. If they do not reply an alert will go off and the illegal drone can safely get arrested. With this system as well, people can get alert if a drone with an active camera is in the area. This will be the first step to make people accept drones in their personal space.

From the FMEA one big issue is a fatal outcome because of drones falling or crashing. Recommended solution for this is emergency parachute, yearly inspections or restrictions for what drone can fly in which weather. Another problem that came up were collisions this were solved which sensors and different altitude for different directions for the drones e.g. all drones that flying north had the same altitude. Battery driven drones have some issues with slow charging. This can be solved with charging stations or parking slots that have an extra battery that is full and ready to use. If this battery change system should work the battery for drones need to be standard. Other things are the treatment of goods. If it is not well secured the goods may fall off. A solution could be that people that going to deliver goods need a license for delivering.

2.2.2.2 Construction

Buildings

For a future with many drones, the infrastructure of most buildings must be greatly adapted. The buildings need a communication system to interact with the drones. They can check the identity of the drone independently of the central computer system. If the drone does not respond or does not respond correctly, the building can trigger an alarm and react with various actions. This could be an infrared laser or with a catching net to get the drone down. Sensitive industrial buildings and government buildings would have much more advanced security measures. To protect privacy and intellectual property, only specially mirrored window panes are used through which it is not possible to film.
The buildings must not only be able to protect themselves, but also meet the new requirements. In the age of drones, buildings must have special loading and unloading devices. In industry, boxes are not large enough. Entire halls will have to be built.

Parking stations

Flying requires energy. To supply all the drones with enough energy, many charging stations are needed. These charging stations are less comparable to today's petrol stations. More like a parking slot where the car is filled up right away. The empty battery can be replaced with a full one for maximum rapid charging. If a drone needs energy but all charging stations are occupied, the control system forces an almost full drone to leave the station. This is controlled by a prioritization algorithm. The same control system also delegates the approaching and departing drones and makes sure that there are no collisions. The charging stations are mounted on the roofs and walls of the buildings. This can be an industrial building, a home of one's own or a government building. A simple payment system is used for billing. Each drone has a chip that records how long it has been parked and how much energy has been consumed. The price is then calculated and used to invoice. Bigger charging stations also have service stations which checks the drones and repairs them if necessary. But even smaller stations have an intelligent control system that checks the function of the software and, if necessary, prevents the drone from continuing its flight.

2.2.2.3 Traffic System

To manage the drone traffic in general, the traffic rules in the air traffic were adopted as a role model. For example, to prevent the aircraft from colliding, the aircraft movements of all major traffic machines are controlled and warned by a tower. Furthermore, the tower determines the speed and the flight altitude. Our vision is for the drones to be completely controlled by a central computer that follows the following rules[15, 16]:

Rule	Function
Speed limit	The speed limit is designed to prevent major and serious accidents. In addition, it is easier to control the drone at a slower speed.
Weight limit	The weight limit has the same function as the speed limit. First, a light drone is easier to control than a heavy one. In addition, the possible damage in a crash would be lower.
Height range	A drone must fly at a certain altitude to avoid possible collisions. A too low altitude would be too dangerous for humans as well as animals and trees. If the altitude is too high, the risk of losing control of the drone and the possible collision with other flying objects such as a helicopter or aircraft would be too great. Furthermore, each flight direction is assigned a certain height slot to avoid collisions between drones.
Prohibited territories	In areas where the drone presents a certain risk of accidents, use is strictly prohibited. This is especially true in areas where many people are present or in the border area of airports.
Obligation to connect	All drones must be permanently connected to a central computer. In addition, the computer should have certain access privileges, such as speed or angle of flight, to avoid accidents.
Licenses and other conditions	Every drone-owner must have a drone-driving license. Each drone must be registered and have a virtual (for the central computer) and physical license plate. In addition, every drone must be insured so that financial liability is also regulated and secured in the event of an unexpected accident.

Table 4: Traffic Rules

[15] (Lufthansa AG, 2018)
[16] (Perlman, 2017)

2.2.2.4 Central Computer

The central computer is designed to be connected to any drone. In addition, this computer can control the speed of a drone as well as other parameters such as flight angle, flight direction, flight altitude, etc.

Another aspect is that the central computer also receives information from the drones and processes it. An example would be if a drone detected a bird in its trajectory, the central computer would then steer the drone to avoid a collision. Furthermore, with other drones that are affected by the flight path correction, the orbit is changed in such a way that no collision occurs.

In addition, the central computer should also be used to detect illegal drones if necessary. To achieve this, all drones should be connected in a certain radius to precisely locate this intruder with bundled sensor force.

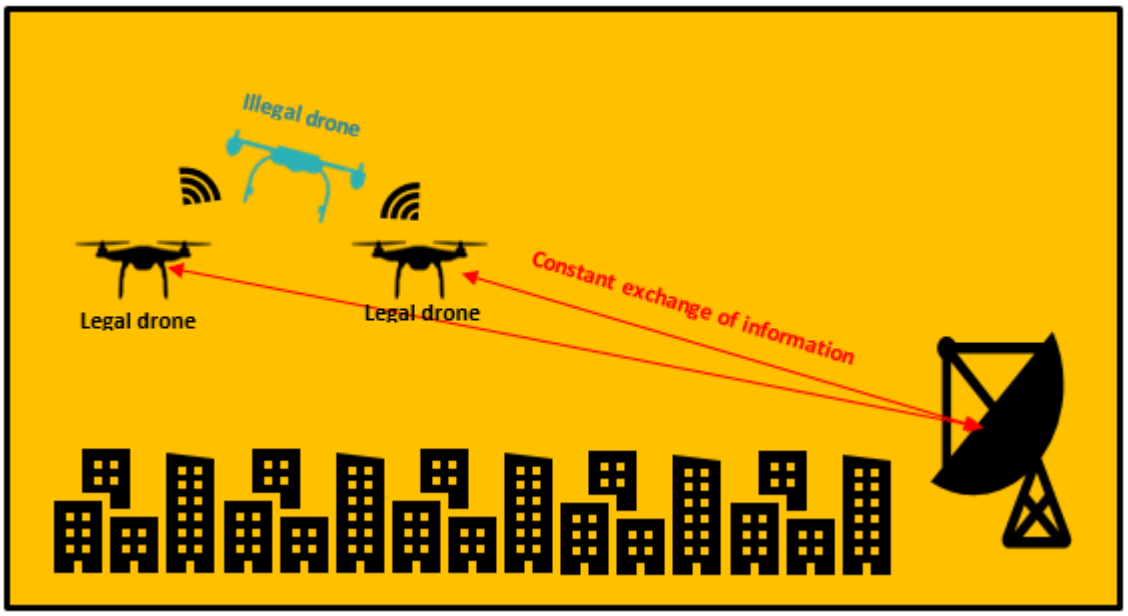

Figure 4: Detecting and locating an illegal drone.

2.2.3 Economic Efficient

Efficiency means not always the same. In general, a distinction must be made between economic and ecological efficiency. Economic efficiency is a "decision criterion that selects from several ecologically equally effective measures (ecological accuracy) the one that is associated with the lowest economic costs (also called cost efficiency).[17]

$$\mathbf{K_{Drone}(x) = MIN[O_1, O_2 \dots O_n]}$$

$K_{Drone}(X)$	Cost of input per output by using a drone for a certain operation.
O_n	A certain system or process to do this operation

[17] (Industrie- und Handelskammer Nürnberg für Mittelfranken, 2015)

3 Roadmap to acceptance

The way to a drone land leads via the approach of the technology acceptance method, which was already mentioned in chapter **2.2.1**. Here the drones are not introduced from zero to 100% in an urban area, but the frequency is increased step by step. This gives people the opportunity to get used to the drone and to accept it. To reach the absolute acceptance, the advantages of the drone must exceed the alleged disadvantages clearly.

The plan is to establish the first drone country not in Western Europe or another established industrial nation, but in a country where the infrastructure is far below the standard of other nations, an example would be sub-Saharan Africa. The goal would be to refer to these poor countries and make the drone attractive to other (rich) countries as an innovation.

1. Milestone	
Africa (development aid)	At present, most central African states have inadequately developed vehicle infrastructures. This makes the transfer of a particularly important good very time-consuming. For example, if a hospital absolutely needs a certain medicine or a special type of blood to save a human being. It is argued that the affected person would have died anyway, because the transport with others would have taken too long for rescue and thus the risk of a loss of goods of the drone is accepted, because it only increases the survival chances.

Table 5: Road to acceptance 1. Milestone

2. Milestone	
Rescue People (development Country's)	After the successful introduction of the drone in poor countries, the acceptance of other countries to use the drone in emergency or disaster situations is increasing. The focus is that the fire brigade or a hospital should use the drone to save lives. The fire department could use you in a disaster such as a forest fire or an avalanche to detect and locate people with an infrared camera. A hospital could, as in Africa, send important medical goods such as blood, medicine or organs.

Table 6: Road to acceptance 2. Milestone

3. Milestone	
Industry (Own territory)	Now that the drones are also being used successfully as rescue machines in Western Europe and other industrialized countries, the general acceptance of their use and further liberalization of their use is increasing. At first, the industries are allowed to use the machines, but with strong regulations such as that the use is only allowed on their own soil. In agriculture in particular, drones can perform important tasks such as harvesting fruit or spraying pesticides, as well as drones can perform bees' tasks and pollinate plants to counter bee decline. In other areas, drones could take over jobs where there is a high risk of accidents. At height, they are working like repairs on a wind turbine or a high-voltage conductor. Jobs such as window cleaning for high-rise buildings can also be replaced in this way. The argument that jobs are lost by drones must be rejected with the whitening to computers, as new technologies also create new jobs, such as manufacturing, repairing and maintaining drones.

Table 7: Road to acceptance 3. Milestone

4. Milestone	
Privat (Service Industry)	The last big milestone in the acceptance would be the use for the private person. According to our vision, no private person owns a drone but uses their performance. For example, if an important parcel is to be sent, you buy this service from the post office. The drones are now completely controlled by the central computer (**Chapter 2.2.2.4**). This kind of accidents are minimized. The fear of the citizens that too many drones are now in the air can be counteracted by taxes, thus the resource air is also used efficiently and a free raider problem is avoided. The law also regulates the problems of privacy in which all data must be encrypted and cameras on drones are generally prohibited. In addition, technological development is also starting here, companies now recognize the potential of drones and will try to make these more efficient. As mentioned in **table 3**, the aim would be to make drones invisible and noiseless to minimize the negative impact on people and the environment. Another aspect would be to adapt the infrastructure to the new technologies in addition to the further development of the drone. One idea would be that drones would no longer use batteries but would satisfy your energy needs by a laser source (e.g. towers).

Table 8: Road to acceptance 4. Milestone

4 Conclusion

The conclusion of this scientific work is the implementation of the drone is currently not only failing due to the lack of technological maturity or its economic efficiency, but also due to the acceptance of the population.

To solve this problem, people will be slowly introduced to the new technology step by step. An integral part of this implementation is the first Droneland will not be implemented in Western Europe or another established industrial country, but in Africa.

The tactic "do something good and talk about it", also called Public Relation, is used. The calculation here would be to show people from the first world that the technology can be used positively.

This initial action is the pivotal point of the drone's implementation in Western Europe. As soon as the drone is successfully used its usage will grow synchronously with the technology.

In our vision, no private person owns a drone but uses only his services. That is to be evaluated like with the course, no privately owns a course but only its services.
To realize this complete automation an implementation of a central computer is inevitable.

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V. Appendix

DISC – Personality – test

This online DISC assessment is designed to test personality by calculating your personal DISC profile based on your everyday typical behavior. Simply fill out the inventory like you would with other online personality tests

Student	D;I;S;C	Descriptions
Pragash Yogarasa	D = 39% I = 18% S = 30% C = 12%	You have a strong inner motivation create and implement new ideas. You handle pressure well -you strive for excellence and except others to do the same. You are innovative but tend to avoid risk taking
Tobias Persson	D = 28% I = 19% S = 39% C = 15%	You are a clear thinker. You have an inner need to be objective and analytical. You like to pursue a definite course of action. You respond to logic rather than emotion. You are likely to be particularly good at handling challenging technical assignments. You have a strong inner motivation to attain personal goals. You like to become 'the expert' in your chosen field.
Tom Noordink	D = 29% I = 26% S = 24% C = 21%	Your most obvious behavioural style is probably Dominant, followed by Influence. When you clearly first have Dominant and then Influence as the most important behavioural style, the positive impression you then make on people is as follows: You have a strong inner motivation to influence people and circumstances. You live up in performance-oriented situations or through challenging assignments. The tensions and pressures of your work and daily life will probably not reduce your effectiveness and enthusiasm.
Marco Künzle	D = 29% I = 34% S = 20% C = 17%	You are socially oriented. You have a strong self-motivation to get to know people in all walks of life and to nurture those relationships. You have a natural enthusiasm for all types of ideas and projects – your own and other

		people´s. People are likely to describe you as gregarious, persuasive and optimistic.
Simon Sammoun	D = 21% I = 36% S =26% C = 17%	You are an approachable and understanding person. Your optimism encourages you to look for the best in others. You are likely to be a good listener and offer constructive advice rather that imposing your own ideas and the values on others. Developing and maintaining relationships – at work adapt play in important to you.
Joyce	D = 20% I = 30% S = 20% C = 29%	You have the ability to work with a team and make things happen. You are motivated to improvise and find new solutions. You are resourceful and compelling. In terms of relationships with others you are likely to be assertive rather than aggressive.