On the validation of the initial step of an upfront system implementation evaluation framework: the fire brigade case

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Introduction

In Högler et al. (2015) a framework is described that, when applied, should deliver insight into the value of a (mobile) IT system, before it is being implemented. The framework has been developed because of a lack of such insight (other frameworks merely focusing on monetary effects, neither taking into account singularities of mobile technologies). The framework consists of 3 pillars with 7 included activities. Figure 1 shows the framework, also identifying interdependencies between the activities and their inputs and outputs.
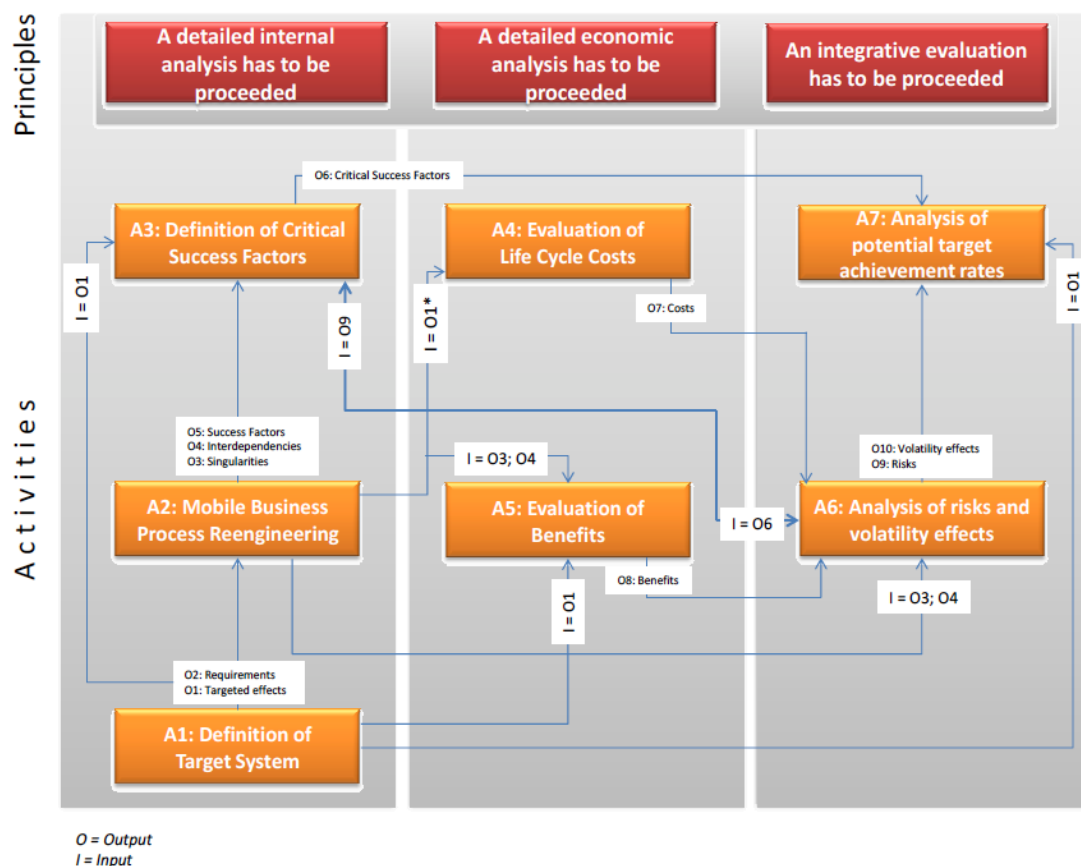

Figure 1: Integrative Framework for Mobile Systems (Högler et al., 2015)

A description of each of the activities from figure 1 is taken from Högler & Versendaal (2016):

1. "Activity 1: Definition of the target system by following the multi-attribute decision making (Hwang & Yoon 1981); this activity outlines a

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procedure for defining the target system leveraging the Analytical Hierarchy Process (AHP) (Saaty 1996) which is extended by following activities (see figure 2), differing fundamentally from previous approaches:

- interdependence analysis between individual objectives (Kirchmer 1999; Drews & Hillebrand 2010; Rückle & Behn 2007);
- consideration of the effective strength of the objectives and the probability of occurrence of interdependencies (Klabon 2007; Charette 1991) and thus their respective value; and
- weighting of objectives in the context of these latter two aspects.

[...]

2. Activity 2: Mobile Business Process Reengineering as proposed by the authors builds upon Mobile Process Landscaping (Gruhn & Wellen 2001; Köhler & Gruhn 2004).
3. Activity 3: Definition of critical success factors, their interdependencies, correlation analysis and weighting (Iqbal et al. 2015; Nysveen et al. 2015; Hway-Boon & Yu 2006).
4. Activity 4: Evaluation of life cycle costs (Wild & Herges 2000; Berghout et al. 2011), performed by identifying costs during the whole lifecycle of mobile systems including the preliminary phase, utilization phase and disposal phase.
5. Activity 5: The evaluation of benefits, based on the total benefit of ownership model (Gadatsch & Mayer 2004), involves the capture of cost savings and non-monetary benefits or qualitative and strategic variables which are not considered in the traditional approaches of economic evaluation.
6. Activity 6: Sensitivity analysis: As an uncertainty of the results achieved in the previous steps remains, a sensitivity analysis is conducted to check the stability of results. Particularly the variables success factors (Corsten 2000; Rockart 1979), risks (Kronsteiner & Thurnher 2009) and the accompanying volatility effects (Kulk & Verhoef 2008; Singh & Vyas 2012) are analyzed.
7. Activity 7: Analysis of potential target achievement rates: Based on the results of the sensitivity analysis, the potential achievement rates can be determined. To do so, results of activity 1 (target system), activity 2 (current and target processes incl. key (performance) indicators) and activity 6 (volatility effects) are merged." (pp 3-4).

Although both papers (Högler et al., 2015; Högler & Versendaal, 2016) provide an evaluation of this integrative framework for mobile systems to some extent, in both papers it is suggested that effort is needed in validating it more extensively. In a separate validation by an e-health mobile app (Nursemapp, 2017) it is furthermore suggested that especially the first activity of the integrative framework needs additional validation. It is therefore that we focus on the validation of the 'Target system definition' by a separate case study.

The separate steps of the first activity of the integrative framework are illustrated in Figure 2.
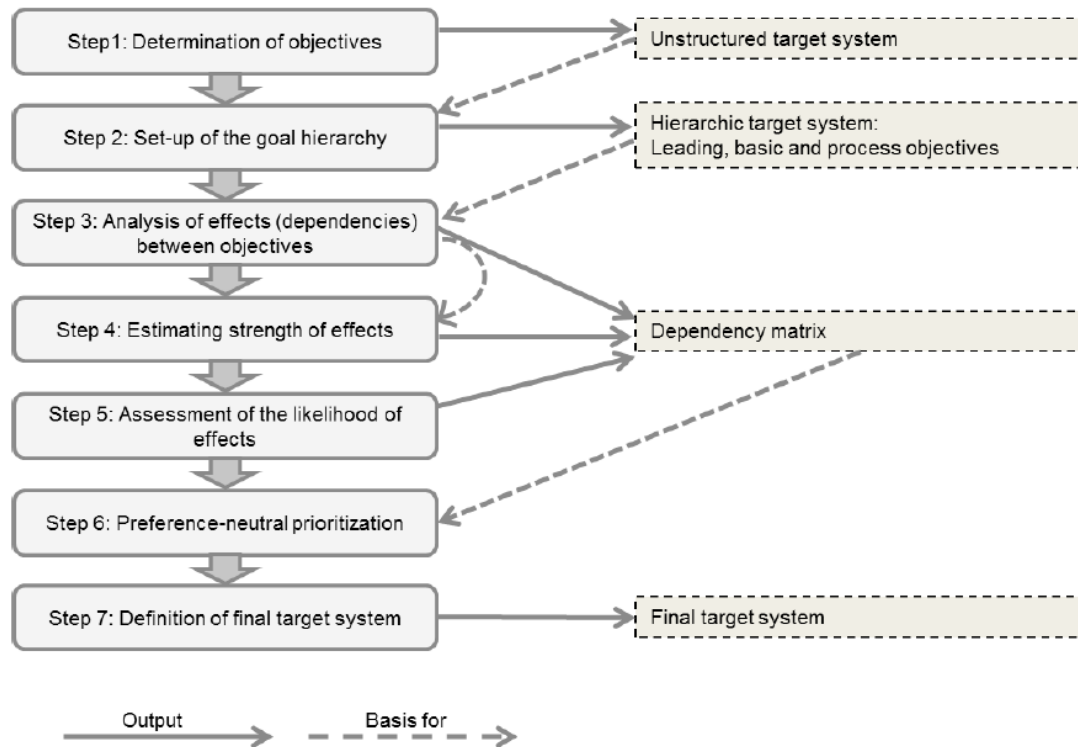
Figure 2: Steps of the first activity of the integrative framework, from Högler & Versendaal (2016)

The steps from Figure 2 are described in detail by Högler & Versendaal (2016):

1. "First, objectives are determined e.g. by task observation, in a workshop or from interviews with the help of a questionnaire. An unstructured target system contains all gathered objectives.
2. In step 2, the identified objectives are brought in a hierarchical relationship (what we define in levels 'key objectives', 'basic objectives' and 'process objectives'). A goal hierarchy is only complete if "each element of a hierarchy level has a direct relationship to the next higher element [...]" (Ahlert 2003, p. 37). [...]
3. In the 3rd step, the identified process objectives are evaluated in a paired comparison concerning their mutual, direct interdependencies. The aim of this comparison is to identify particularly competing objectives, as setting priorities among them reduces inconsistencies in the target system.
4. The strength of interdependencies is estimated in step 4, which is largely subjective and based on experience of the involved interviewees. The scale for the estimation can be chosen freely, but it should not be too fine-grained, since this would cause pseudo-accuracies (Meixner & Haas 2012, p. 202). Thus, the authors propose a three-level scale (low, medium, strong effects).
5. Next the estimation of their likelihood (probability) is needed (step 5). It is methodologically based on risk management (e.g. NIST 2012, p. 23) and in practice on the experience of the involved individuals. Again a three-level scale is proposed to estimate the likelihood of effects: effect is possible, but improbable; effect is probable; effect will occur with the utmost probability. It is necessary that the interviewees agree internally

on the nature of the effects – but not necessarily on their effective strength and likelihood, since without such an agreement, the target-relation-matrix cannot be installed. The individual effects between objectives should not be regarded as absolute and as in all circumstances occurring, but rather they indicate general trends which may be reinforced, mitigated or neutralized under certain circumstances, or by the use of respective (appropriate or inappropriate) systems.

6. To ensure that mainly high priority objectives are pursued, which have the greatest benefit, competing relations between objectives must be detected. This is done in the 6th step, where the objective priorities are determined. Based on the prospect theory by Kahneman & Tversky (1979), a preference-neutral weighting assumes that the weight of an objective can be determined by its active and passive value. To receive these values, for each objective its strength of effects is multiplied with the likelihood of its occurrence. The resulting (mathematical) products are subsequently summed up for each objective in both the horizontal (so-called "active value") as well as in the vertical ("passive value") axis of the table. This procedure is legitimate insofar as the value of an effect can be defined as the product of strength of effects and their likelihood of occurrence (see also Kahneman & Tversky, 1979). A threshold should be defined by a decision maker which allows the classification of objectives in different priorities. As there is no standardized procedure for defining a threshold, the authors propose to choose a threshold that divides the objectives 'on sight'.

7. In the last step (7) the final target system is defined by consolidating the earlier steps and assigning final priorities to objectives."

Case context

As criteria for choosing our case for validation, we can now define:

- it should address the first activity (target system definition) validation;
- it should relate to a major system implementation, in a large organization, currently being prepared;
- it should be easily made clear to the organization that carefully thinking about targets and goals, upfront system implementation, is of utmost important;
- moreover, there should be willingness from the organization to participate in the validation activity.

The Dutch fire brigade consists of nearly 28.000 firemen. The personnel (of which about 2/3rd are volunteers) should be kept long life professionally skilled.

For the NL, country-wide, the fire brigade has acquired Three Ships N@tschool! Electronic Learning Environment (ELE) as a system for supporting the training for staying life-long professionally skilled ('vakbekwaam blijven'). After developing a number of trial courses and digitizing another number of existing training courses, the management of 6 of the 25 fire brigade regions (i.e. region 4, 5, 6, 7, 8 and 25, see Figure 3, representing almost 6.000 firemen), together with the so called 'BOGO' educational institute for the fire brigade, decided to take a leading role in developing a showcase how to implement the ELE.
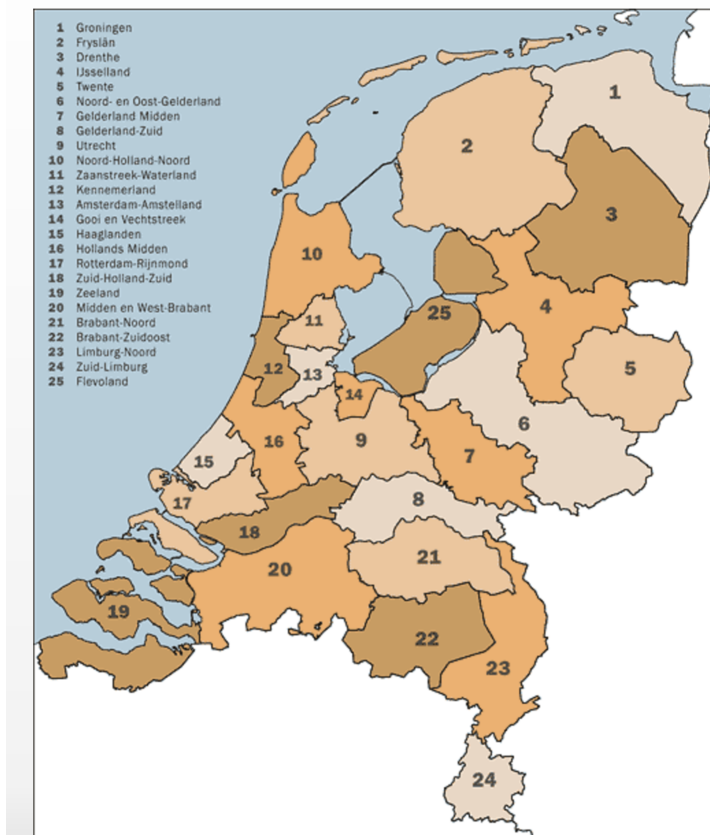
Figure 3: Fire brigade regions in the NL (source: veiligheid.org)

With the existing good relations with the heads of the mentioned regions, the researchers feel comfortable in meeting the above mentioned criteria for case selection. Note that the implementation of the ELE has *mobile* components (facilitating time and place independent learning), but it does not specifically focus on mobile learning or mobile processes. For executing the first activity of the framework the researchers do not consider this as a necessary prerequisite nor essential in the context of the framework's first activity validation, as the integrative framework was developed as a generic approach that is meant for evaluating IT systems in general.

In taking the pilot implementation at the 6 Dutch fire brigade regions as our case study, we check the following (see also Hevner et al. (2004; p 85) for the mentioned standard validation criteria):

1. Can all steps of the first activity of the integrative framework be performed successfully?
2. Is the execution of the first activity of the integrative framework considered to be accurate?
3. Is the execution of the first activity of the integrative framework considered to be useful?

Technical Report

Validation protocol

We take the standard research design template of Maimbo & Pervan (2005) for describing our validation protocol, see Table 1.

Section	Protocol details regarding the Dutch fire brigade case
Preamble	The head and management of region 7 has, on behalf of the other 5 regions, approved execution of the validation of the first activity of the integrative framework in conjunction with the preparation of the implementation of the ELE. This is confirmed in e-mails between the fire brigade and the researchers.
General	Högler et al. (2015) describe an integrative framework for a priori evaluation of the effects of (mobile) IT system implementation. For further validating the integrative framework we choose to focus on validating the first activity of the framework.
Procedures	In determining the utility and efficacy of the first activity of the integrative framework, we execute a brainstorm with the 6 region heads for determining the goals/targets/objectives of the ELE implementation (step 1); one of the researchers is managing the process during brainstorming, while a secretary of the fire brigade observes and takes notes. Once we have determined agreed upon objectives among the region heads, the secretary involved in the brainstorm is asked to create the dependency matrix (step 3, 4 and 5). In parallel the researchers will construct an objectives hierarchy. The secretary checks the constructed objectives hierarchy. Once approved the secretary and the researchers together perform step 6 (defining high, medium and low priority process objectives from the values in the dependency matrix, only considering process objectives), and step 7 (describing the final target system, with prioritized objectives).
Research instrument(s)	We will use a template in Excel that supports all steps (see appendix A) and guides the researchers in data analysis
Data analysis guidelines	Once data is collected through brainstorming (step 1) and in creating the dependency matrix (step 3, 4 and 5), an important data analysis concept is the interpretation of the calculated *active and passive values* from the dependency matrix. The *active* value of an objective is the degree to which this objective influences other objectives; the *passive* value of an objective is the degree indicating how much this objective is influenced by other objectives. Not explicitly taking into account an objective with high active values, has also consequences for attaining other objectives; not taking into account an objective with high passive value is possibly not too bad as other objectives add to the attainability of that particular objective. Active and passive values of objectives help in assigning priorities to the objectives.
Appendix	• In e-mails between the fire brigade and the researchers confirmation of participation in the validation is indicated. • Appendix A shows the used template for creating the dependency matrix and showing the prioritization

Table 1: Validation protocol, using the template of Maimbo & Pervan (2005)

Validation results and analysis

Step 1: Determination of objectives

On 13th of October 2016, the 6 heads of the regions came together, to dedicate the afternoon for defining the target system under guidance of the researchers. In the morning of the same day the heads had conversations with some training experts, ELE-experts and the researchers to discuss the pitfalls, success factors and best practices of the ELE-prototype implementations so far. Because of this the 6 heads were in the afternoon considered to be fully up to speed to make good contributions to defining the target system in the afternoon.

Technical Report

The afternoon session of October 13th, 2016 proceeded as follows:
   a) The heads of the regions, for themselves, took 30 minutes time to describe individual targets on separate sticky notes.
   b) Each of the heads explained shortly each of the identified individual targets. Making a plenary round, guided (process managed) by one of the researchers.
   c) Subsequently, each of the heads put the sticky notes on the brown/white-paper on the wall, trying to combine / stick together similar targets from their colleagues
   d) One of the researchers (as process manager of the brainstorm session) took 15 minutes time to try to make up a proper clustering of each of the sticky notes.
   e) Under guidance of one of the researchers, plenary with the 6 heads, the categorization and targets were discussed. Resulting in reducing the number of individual targets, yet also adding one or two. The results are depicted in the following figures:

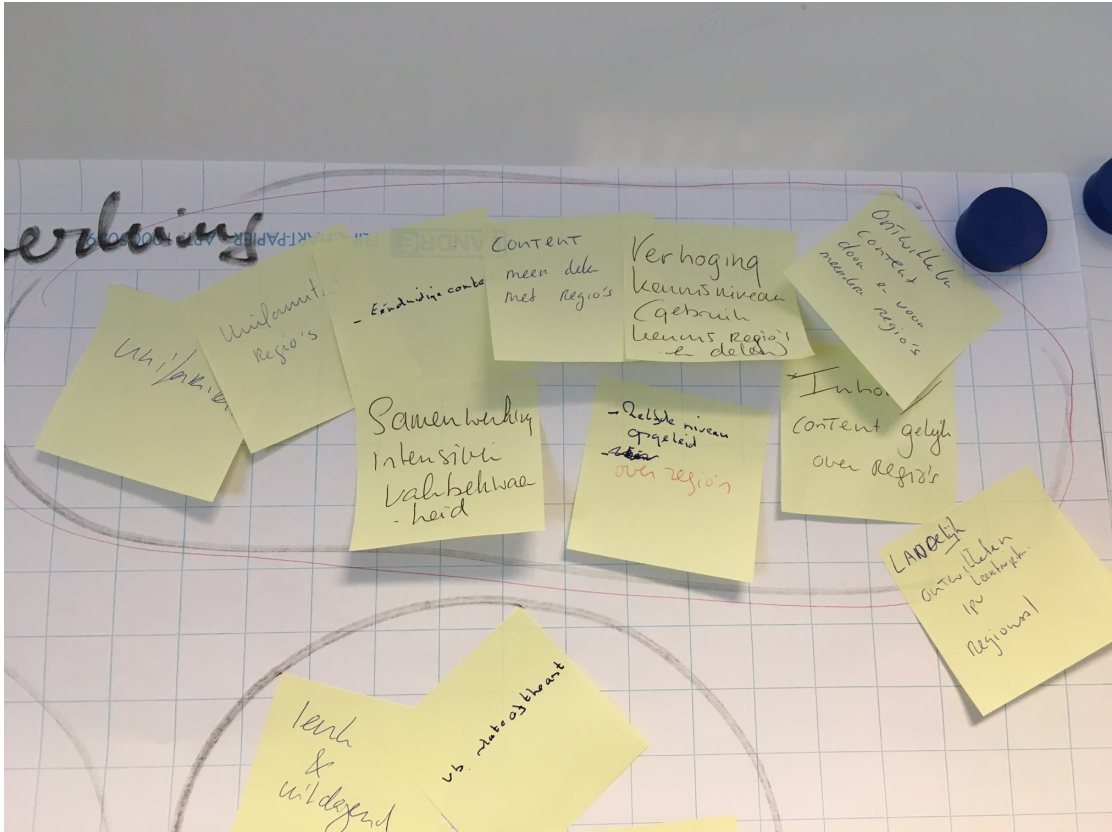*Figure 4: Overall view of perceived correct individual targets*

Figure 5: Clustering of objectives dealing with 'cooperation between regions'
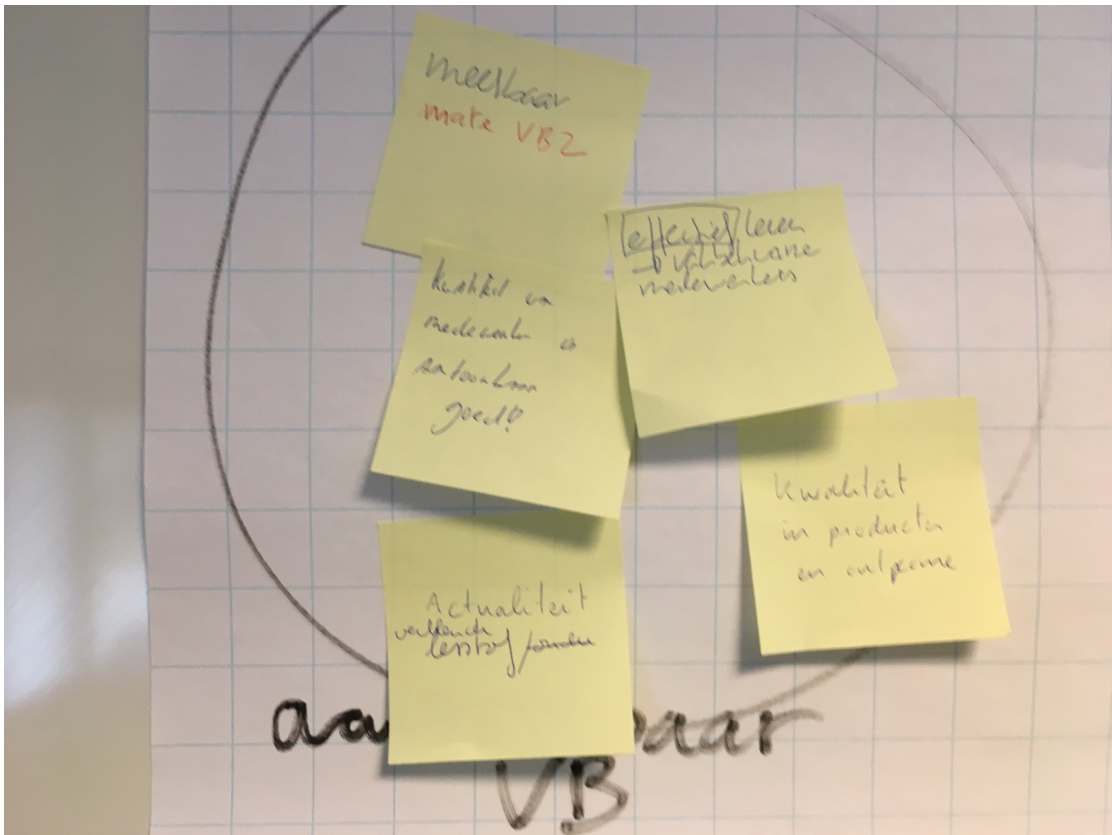

Figure 6: Clustering of objectives dealing with being 'identifiably professionally skilled'
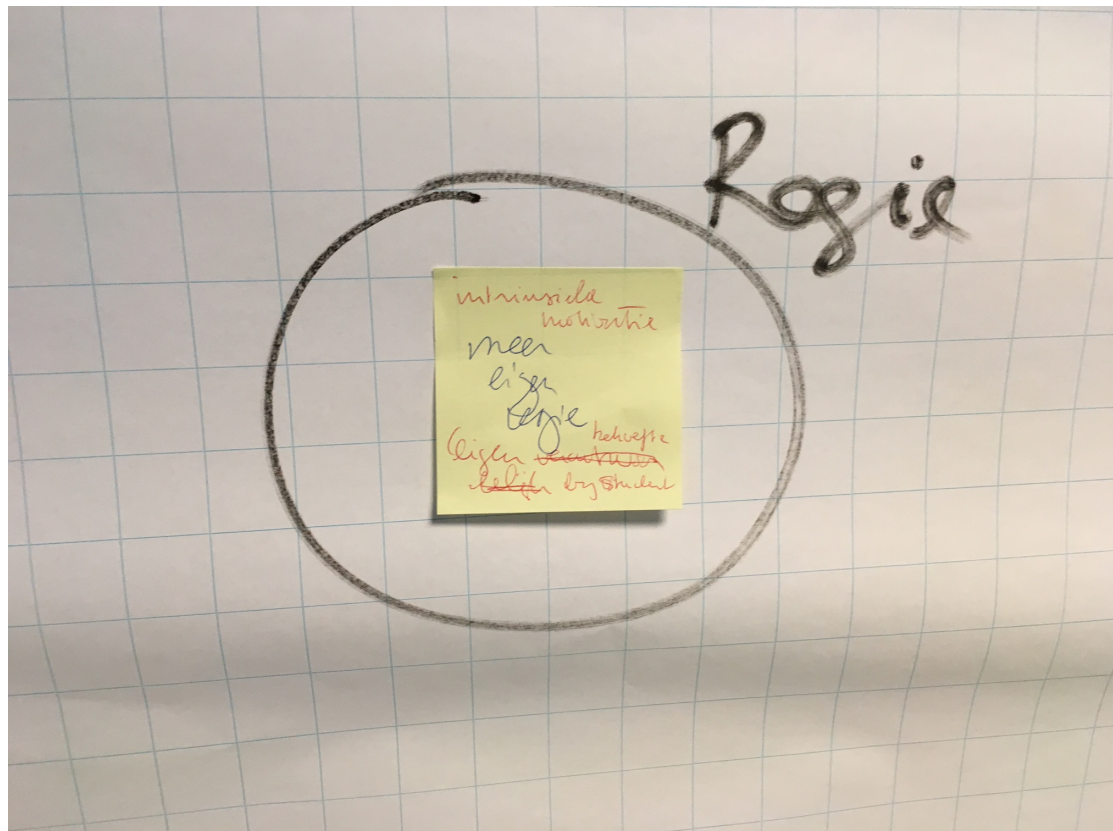
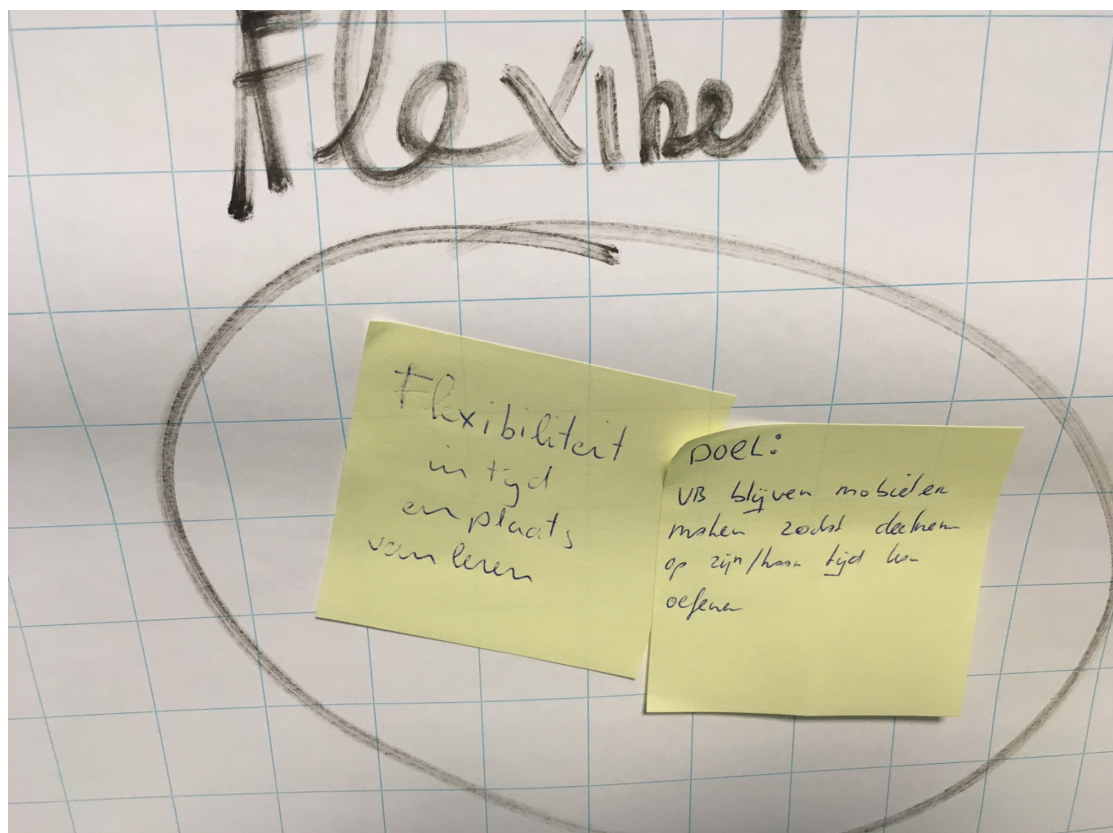*Figure 7: Objective relating to 'self-control'*

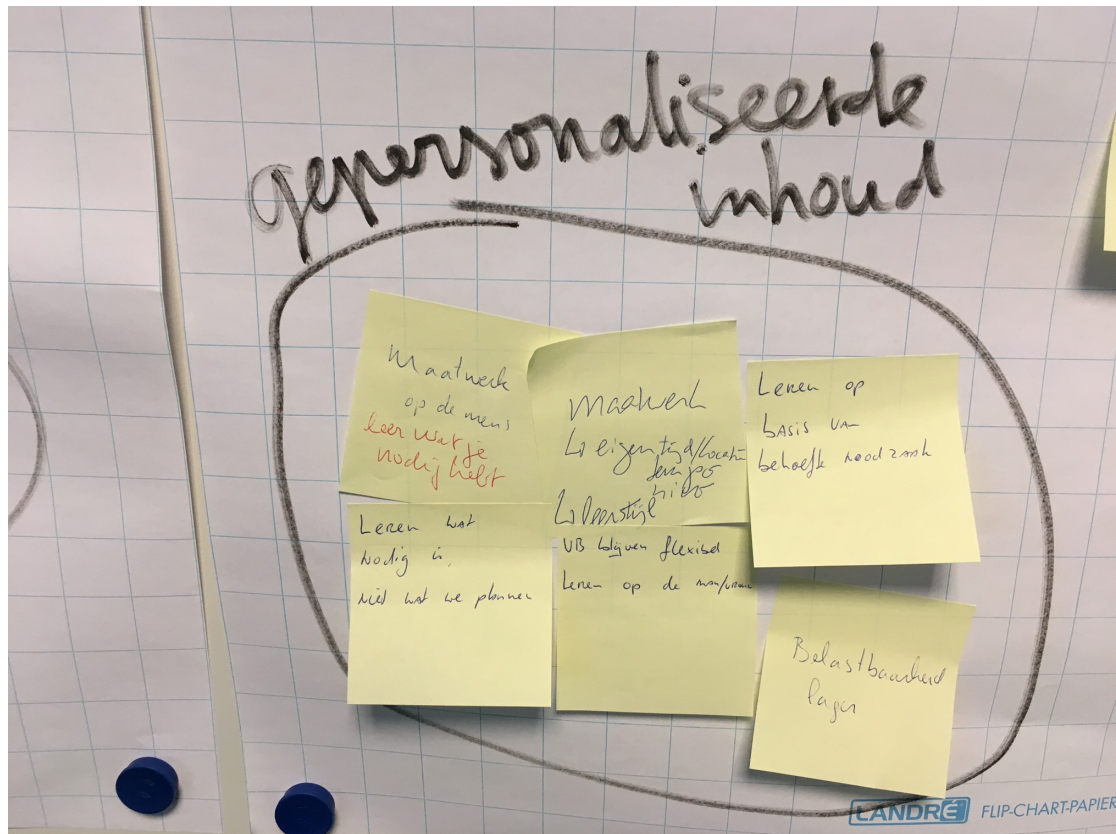*Figure 8: Objectives relating to 'flexibility in learning'*

Figure 9: Cluster of objectives relating to 'personalized learning'
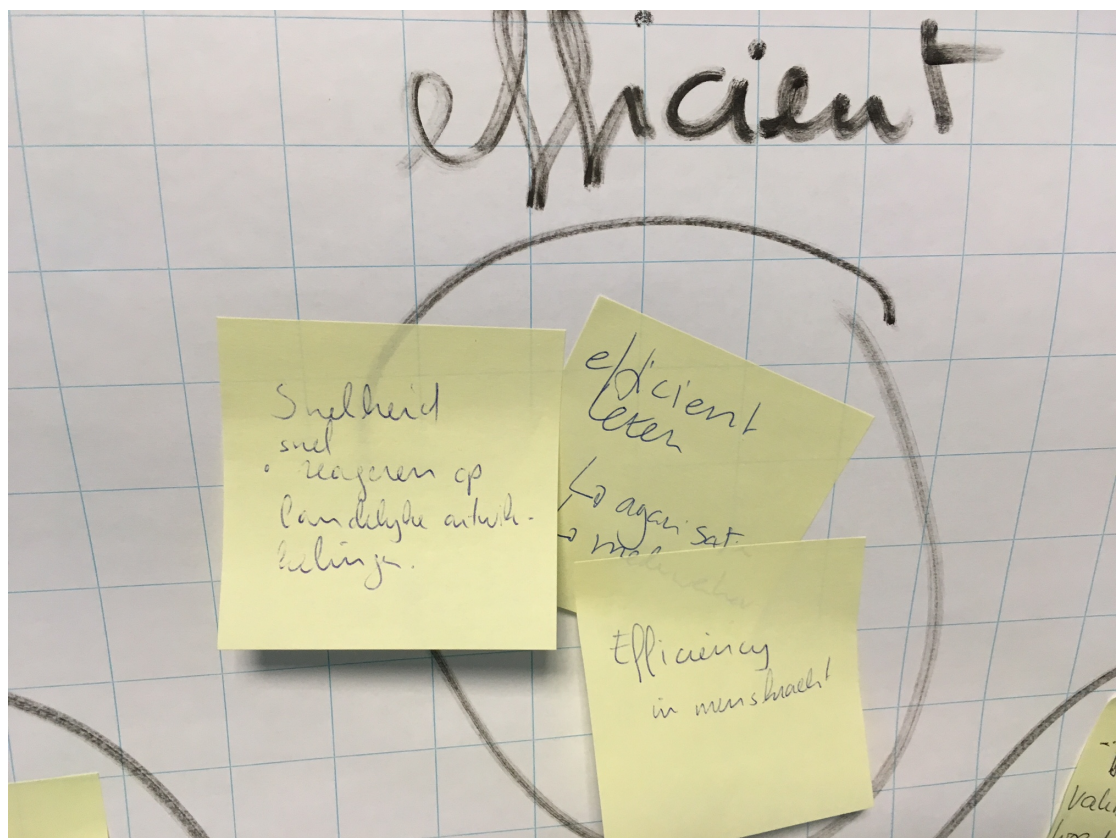

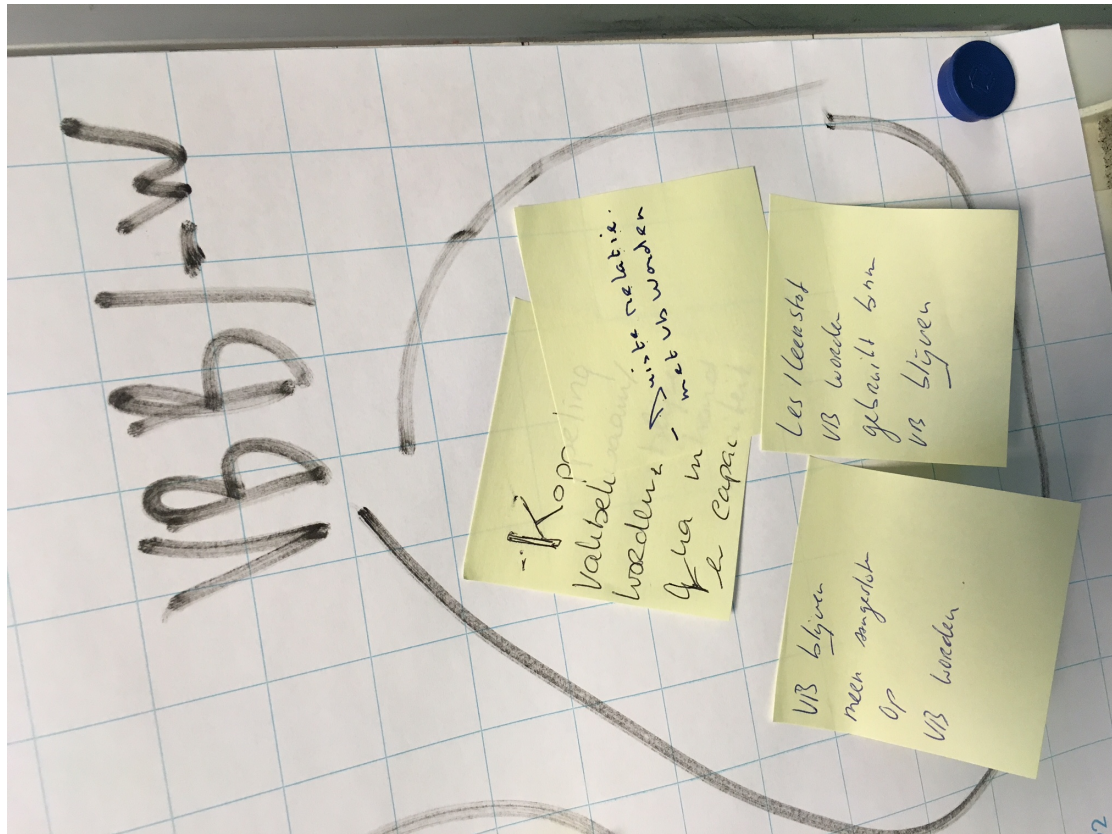Figure 10: Cluster of objectives relating to 'efficient learning'

Figure 11: Cluster of objectives regarding 'relation <u>staying</u> professionally skilled with <u>becoming</u> professionally skilled'

The researchers made a proposal from this first objectives identification, and translated them to English. The secretary present during the brainstorm checked the translations and agreed after some discussion to the list and its translation. The resulting list is depicted in Table 2.

Original objective (in Dutch)	English translation
Uniformiteit in verblende producten tussen regio's	Uniformity of learning material between different regions
Eenduidige context van opleiden	Uniform context for learning
Content meer delen met regio's; inhoud/content gelijk over regio's	Shared similar content between regions
Verhoging kennisniveau door gebruik kennis verschillende regio's	Improved knowledge level by sharing knowledge between regions
Ontwikkelen content door en voor meerdere regio's	Develop content by and for different regions
Landelijk ontwikkelen van leertraject ipv regionaal	Country level learning process (instead of regional)
Zelfde niveau opgeleid over regio's	Firemen equally educated in different regions
Samenwerking intensiever mbt vakbekwaamheid	More intensive cooperation with regard to life-long professional skills
Leuk en uitdagende leeromgeving	Nice & challenging learning environment

State-of-the-art leeromgeving	State of the Art learning environment
Hoge kwaliteit leerproducten	High quality learning material
Inspirerende leeromgeving	Inspiring learning environment
Meetbare mate van vakbekwaam zijn	Measurable level of professional skills
Effectief leren leidend tot vakbekwame medewerkers	Effective learning leading to life-long professional skills
Kwaliteit van medewerkers is aantoonbaar goed	Quality of firemen´s skills demonstrably good
Kwaliteit in outcome	Quality in outcome
Actualiteit van verblende lesstof	Currentness of learning material
Meer eigen regie (intrinsieke motivatie) van de medewerker op eigen leeractiviteiten	More own responsibility (intrinsic motivation) for firemen for their own learning activities / Learning process
Flexibiliteit in tijd en plaats van leren	Flexibility in time and place of learning
Mobieler maken vakbekwaam blijven zodat medewerker op zijn/haar tijd kan oefenen	Place independent (Mobile!) learning so that firemen can learn time independent
Maatwerk op de mens (leer wat je nodig hebt)	Taylor-made training for firemen - learn what you need
Maatwerk leerstijl	Taylor-made learning style
Leren op basis van behoefte en noodzaak	Learning on basis of need & necessity
Flexibel leren voor de man/vrouw	Flexible learning for firemen
Belastbaarheid voor medewerker lager	Reduce stress & strain for firemen
Leren wat nodig is, niet wat we plannen	Learning what is needed not what is planned
Snelheid (snel nieuwe lesstof op basis van landelijke ontwikkelingen)	Speed (learn quickly new learning material because of country wide developments in fire brigade)
Efficëntie voor organisatie vwb training	Efficiency for organization regarding training
Efficiënt leren voor de medewerker	Efficient learning for firemen
Efficiëncy in mensen en middelen	Efficiency in firemen and means
Koppeling vakbekwaam worden/blijven qua inhoud en capaciteit	Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved
Les- en leerstof vakbekwaam worden gebruikt binnen vakbekwaam blijven	Initial learning materials will be used for life-long learning
Vakbekwaam blijven meer aangesloten op vakbekwaam worden	Staying professional / life-long learning more connected to initial learning

Table 2: List of objectives from the brainstorm, with their English translation

Step 2: Set-up of the objectives hierarchy
In this step, the researchers derived leading (key), basic and process objectives from Table 2. A key objective (first column) is the highest abstraction level of

objectives, representing benefits, then comes the basic objectives (which are still high level), and finally process objectives (concrete lowest level objectives, representing how to achieve the benefits). The process objectives of a particular color will contribute to the basic objectives of that same color, which in turn will contribute to the key objective of that color. Figure 12 illustrates an early version of the objectives hierarchy. Table 3 shows the result of creating the initial hierarchy.
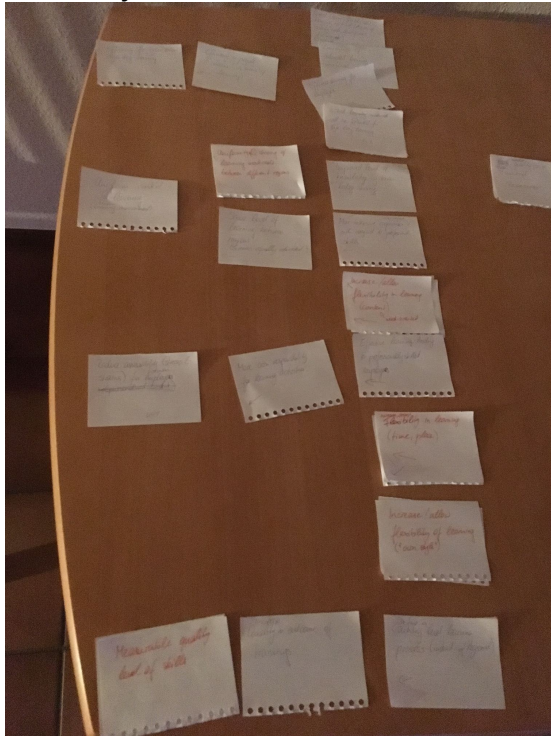

Figure 12: In the process of defining the initial objectives hierarchy

Key objective	Basic objective	Process objective
Eenduidige context van opleiden (Uniform context for learning)	Zelfde niveau opgeleid over regio's (Firemen equally educated in different regions)	Uniformiteit in verblende producten tussen regio's (Uniformity in learning material between different regions) Content meer delen met regio's; inhoud/content gelijk over regio's (Shared similar content between regions) Verhoging kennisniveau door gebruik kennis verschillende regio's (Improved knowledge level by sharing knowledge between regions) Ontwikkelen content door en voor meerdere regio's (Develop content by and for different regions)
Measurable quality level of skills	Kwaliteit in outcome (Quality in outcome)	Landelijk ontwikkelen van leertraject ipv regionaal (Define a (standardised) country level learning process (instead of regional))
Eenduidige context van opleiden (Uniform context for learning)	Zelfde niveau opgeleid over regio's (Firemen equally educated in different regions)	Samenwerking intensiever mbt vakbekwaamheid (More intensive cooperation with regard to life-long professional skills)
Belastbaarheid voor medewerker lager (Reduce stress & strain for firemen)	Meer eigen regie (intrinsieke motivatie) van de medewerker op eigen leeractiviteiten (More own responsibility (intrinsic motivation) for employees for their own learning activities / Learning process)	Effectief leren leidend tot vakbekwame medewerkers (Effective learning leading to life-long professional skills)
Efficëntie voor organisatie vwb training (Efficiency for organisation regarding training)	Efficiëncy in mensen en middelen (Efficiency in firemen and means)	Actualiteit van verblende lesstof (Currentness of learning material)
Belastbaarheid voor medewerker lager (Reduce stress & strain for firemen)	Meer eigen regie (intrinsieke motivatie) van de medewerker op eigen leeractiviteiten (More own responsibility (intrinsic motivation) for employees for their own learning activities / Learning process)	Flexibiliteit in tijd en plaats van leren (Flexibility in time and place of learning) Mobieler maken vakbekwaam blijven zodat medewerker op zijn/haar tijd kan oefenen (Place independent (Mobile!) learning so that employee can learn time independent) Maatwerk op de mens (leer wat je nodig hebt) (Taylormade training for employee - learn what you need) Maatwerk leerstijl (Taylormade learning style) Leren op basis van behoefte en noodzaak (Learning on basis of need & necessity) Flexibel leren voor de man/vrouw (Flexible learning for firemen) Leren wat nodig is, niet wat we plannen (Learning what is needed not what is planned)
Efficëntie voor organisatie vwb training (Efficiency for organisation regarding training)	Efficiëncy in mensen en middelen (Efficiency in firemen and means)	Snelheid (snel nieuwe lesstof op basis van landelijke ontwikkelingen) (Speed (learn quickly new learning material because of country wide developments in firebrigade) Efficiënt leren voor de medewerker (Efficient learning for firemen) Connection of initial with life-long learning (Koppeling vakbekwaam worden/blijven qua inhoud en capaciteit (Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved)) Connection of initial with life-long learning (Les- en leerstof vakbekwaam worden gebruikt binnen vakbekwaam blijven (Initial learning materials will be used for life-long learning) Connection of initial with life-long learning (Vakbekwaam blijven meer aangesloten op vakbekwaam worden (staying professional / life-long learning more conntected to initial learning)

Table 3: Initial hierarchy of objectives

Note that the yellow row, with key objective 'Measurable quality level of skills' has been newly created from two existing identified objectives 'Measurable level of professional skills' and 'Quality of firemen's skills demonstrably good'. This suggested change was agreed by the fire brigade's secretary.

Furthermore, in this step it was suggested to combine the following objectives:
- Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved)
- Initial learning materials will be used for life-long learning
- Staying professional / life-long learning more connected to initial learning

into 1 objective:
- Connection of initial with life-long learning (staying professional / life-long learning more connected to initial learning)

It was also suggested by the researchers to combine the following objectives (basically, letting the first objective be included in the second)
- Learning on basis of need & necessity
- Learning what is needed not what is planned

into the latter objective:
- Learning what is needed not what is planned

Both suggestions were again approved by the secretary of the fire brigade.

Now the resulting hierarchy of objectives is shown in the following Table.

Key objective	Basic objective	Process objective
Uniform context for learning	Firemen equally educated in different regions	Uniformity in learning material between different regions
		Shared similar content between regions
		Improved knowledge level by sharing knowledge between regions
		Develop content by and for different regions
		More intensive cooperation with regard to life-long professional skills
Measurable quality level of skills	Quality in outcome	Define a (standardised) country level learning process (instead of regional)
Reduce stress & strain for firemen	More own responsibility (intrinsic motivation) for employees for their own learning activities / Learning process	Effective learning leading to life-long professional skills
		Flexibility in time and place of learning
		Place independent (Mobile!) learning so that employee can learn time independent
		Taylormade training for employee - learn what you need
		Taylormade learning style
		Flexible learning for firemen
		Learning what is needed not what is planned
Efficiency for organisation regarding training	Efficiency in firemen and means	Currentness of learning material
		Speed (learn quickly new learning material because of country wide developments in firebrigade
		Efficient learning for firemen
		Connection of initial with life-long learning (staying professional / life-long learning more conntected to initial learning)

Table 4: Final hierarchy of objectives

Note that the list contains 17 Process objectives that need to be prioritized.

Step 3-5: Creating the dependency matrix
This procedure was performed by the fire brigade secretary in parallel with Step 2, taking the objectives from Table 2 (not Table 3 or 4) as starting point. Tables 5

and 6 show the results as entered by the secretary for the strengths of possible interdependencies between objectives and their likelihood of occurrence.

Column headers (1–12):
1. Uniformiteit in verblende producten tussen regio's
2. Eenduidige context van opleiden
3. Content meer delen met regio's; inhoud/content gelijk over regio's
4. Verhoging kennisniveau door gebruik kennis verschillende regio's
5. Ontwikkelen content door en voor meerdere regio's
6. Landelijk ontwikkelen van leertraject ipv regionaal
7. Zelfde niveau opgeleid over regio's
8. Samenwerking intensiever mbt vakbekwaamheid
9. Leuk en uitdagende leeromgeving
10. State-of-the-art leeromgeving
11. Hoge kwaliteit leerproducten
12. Inspirerende leeromgeving

	1	2	3	4	5	6	7	8	9	10	11	12
Uniformiteit in verblende producten tussen regio's		2	3	2	3	3	2	2	2	1	2	1
Eenduidige context van opleiden	2		3	3	3	3	3	2	2	1	2	1
Content meer delen met regio's; inhoud/content gelijk over regio's	3	2		3	3	2	2	2	2	1	2	2
Verhoging kennisniveau door gebruik kennis verschillende regio's	2	1	3		3	2	1	2	2	2	2	2
Ontwikkelen content door en voor meerdere regio's	3	2	3	3		1	2	2	2	2	2	1
Landelijk ontwikkelen van leertraject ipv regionaal	3	2	3	1	-1		2	0	1	0	0	1
Zelfde niveau opgeleid over regio's	2	3	3	2	3	1		1	0	0	0	0
Samenwerking intensiever mbt vakbekwaamheid	2	2	3	2	3	-1	1		1	1	1	1
Leuk en uitdagende leeromgeving	1	0	1	2	2	1	1	1		3	2	2
State-of-the-art leeromgeving	0	0	0	0	0	0	0	0	2		1	3
Hoge kwaliteit leerproducten	1	1	1	1	0	0	1	1	1	1		1
Inspirerende leeromgeving	0	0	1	1	1	0	0	0	2	2	1	

Table 5: Snapshot of Strengths of interdependencies between objectives (In Dutch)

	1	2	3	4	5	6	7	8	9	10	11	12
Uniformiteit in verblende producten tussen regio's		2	3	3	3	3	2	2	2	2	2	2
Eenduidige context van opleiden	3		3	2	2	3	3	2	2	2	2	2
Content meer delen met regio's; inhoud/content gelijk over regio's	3	2		3	3	3	3	3	2	2	2	2
Verhoging kennisniveau door gebruik kennis verschillende regio's	3	2	3		3	3	3	3	3	3	3	3
Ontwikkelen content door en voor meerdere regio's	3	2	3	3		2	2	3	3	3	3	3
Landelijk ontwikkelen van leertraject ipv regionaal	3	3	3	3	3		3	2	2	2	2	2
Zelfde niveau opgeleid over regio's	2	2	2	2	2	3		3	2	2	2	2
Samenwerking intensiever mbt vakbekwaamheid	3	3	3	3	3	2	3		2	2	2	2
Leuk en uitdagende leeromgeving	2	2	2	2	2	2	2	2		3	3	3
State-of-the-art leeromgeving	2	2	2	2	2	2	2	2	3		3	3
Hoge kwaliteit leerproducten	2	2	2	2	2	2	2	2	3	3		3
Inspirerende leeromgeving	2	2	2	2	2	2	2	2	3	3	3	

Table 6: Snapshot of Probability of interdependencies between objectives (In Dutch)

Step 6: Preference-neutral prioritization

The two involved researchers discussed via telephone (synchronously) and via e-mail (asynchronously) with the secretary how to take the results from Step 2 (objectives hierarchy) and Step 3-5 (dependency matrix) into an objectives prioritization. First the secretary agreed to take the process objectives of Table 4 as the starting point for showing the active and passive values per objective. Table 7 shows just this. Process objectives are listed in differently colored rows per key objective.

Key objective	Basic objective	Process objective	Active value	Passive Value
Uniform context for learning	Firemen equally educated in different regions	Uniformity in learning material between different regions	107	87
		Shared similar content between regions	107	112
		Improved knowledge level by sharing knowledge between regions	106	83
		Develop content by and for different regions	99	93
		More intensive cooperation with regard to life-long professional skills	95	77
Measurable quality level of skills	Quality in outcome	Define a (standardised) country level learning process (instead of regional)	48	84
Reduce stress & strain for firemen	More own responsibility (intrinsic motivation) for employees for their own learning activities / Learning process	Effective learning leading to life-long professional skills	26	37
		Flexibility in time and place of learning	39	42
		Place independent (Mobile!) learning so that employee can learn time independent	28	47
		Taylormade training for employee - learn what you need	83	50
		Taylormade learning style	85	39
		Flexible learning for firemen	56	62
		Learning what is needed not what is planned	63	60
Efficiency for organisation regarding training	Efficiency in firemen and means	Currentness of learning material	48	42
		Speed (learn quickly new learning material because of country wide developments in firebrigade	28	46
		Efficient learning for firemen	58	56
		Connection of initial with life-long learning (staying professional / life-long learning more conntected to initial learning)	53	56

Table 7: Active and passive values for Process objectives

Subsequently the Active values (X-axis) and Passive values of each of the Process objectives were put in a graph. Objectives were suggested to be categorized (=prioritized) in 4 quadrants:

- Priority A quadrant identifying objectives with a high Active value, and low Passive value;
- Priority B quadrant identifying objectives with a high Active value, and a high Passive value;
- Priority C quadrant identifying objectives with a low Active value, and a low Passive value;
- Priority D quadrant identifying objectives with a low Active value, and a high Passive value.

The horizontal and vertical lines making the division between the quadrants were inserted during a call with the secretary: the secretary was asked to compare two different objectives in terms of their importance to each other (more important or same importance). Within 4 iterations the lines were fixed. First, a vertical and a horizontal line were inserted into the figure. The point of intersection was circa in the middle of the figure. The following procedure was executed as follows for both, the vertical and horizontal line:

a) Two objectives nearby the center of the figure were taken as starting point.
b) The secretary was asked, if these objectives have the same importance (example in Figure 13: "Efficient learning for firemen" and "Learning what is needed not what is planned").

c) If they had the same importance, the vertical line was shifted to the left / the horizontal line was shifted up.
d) The left / upper objective of the previous group was then compared to the next objective that had the next lower active value / higher passive value. Again the secretary was asked if these objectives have the same importance.
e) This procedure was repeated until the lines there was no more adjustment needed which means that there was always a more and a less important objective.
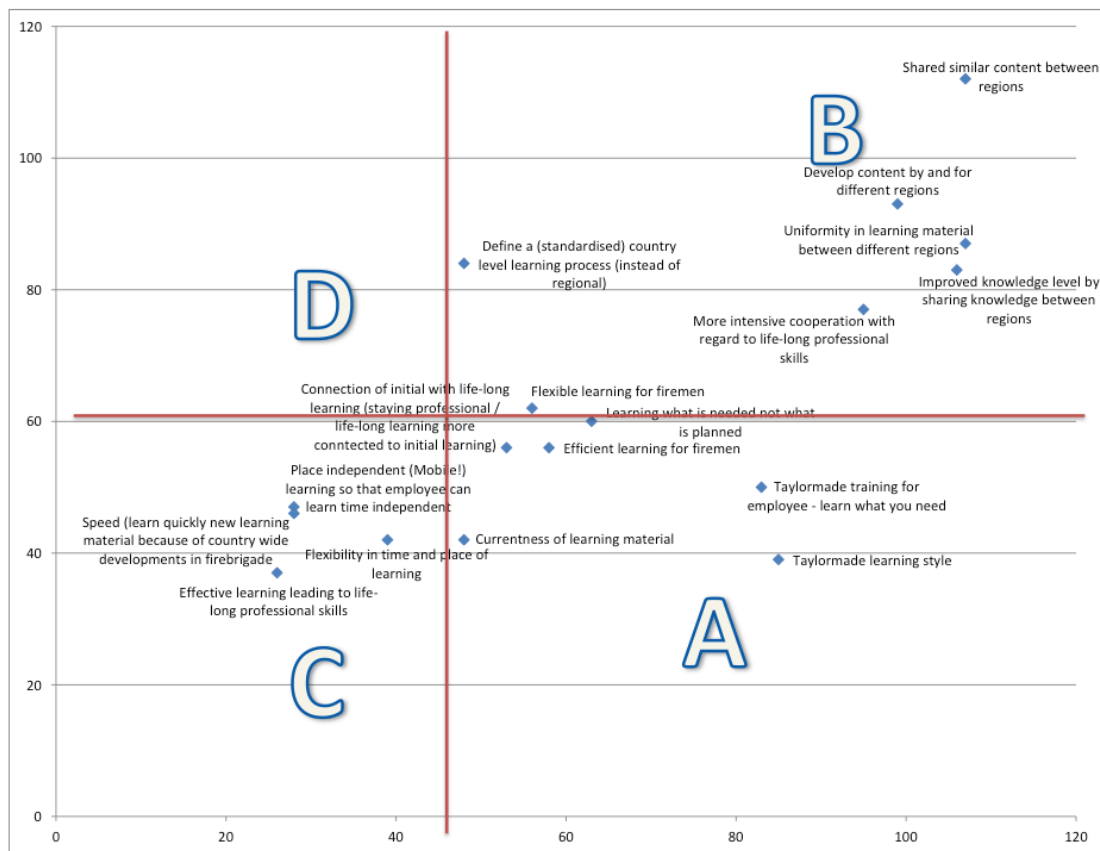
The result is shown in Figure 13

Figure 13: Setting the priority groups regarding the process objectives

Note that there is no priority D objective.

Step 7: Defining the final target system
Table 8 shows the final resulting target system, containing the prioritization of objectives.

Priority A (highest)	Taylor-made learning style
	Taylor-made training for employee (firemen) – learn what you need
	Learning what is needed not what is planned

	Efficient learning for firemen
	Connection of initial with life-long learning
	Currentness of learning material
Priority B	Shared similar content between regions
	Uniformity of learning material between regions
	Improved knowledge level by sharing knowledge between regions
	Develop content by and for different regions
	More intensive cooperation with regard to life-long professional skills
	Flexible learning for firemen
	Define a (standardized) country level learning process (instead of regional)
Priority C (lowest)	Uniform context for learning
	Place independent (Mobile!) learning so that employee can learn time independent
	Speed (learn quickly new learning material because of country wide developments in fire brigade
	Effective learning leading to life-long professional skills

Table 8: Target system definition for implementing an ELE at 6 fire brigade regions in the NL

Some further analysis

Not anticipated in the case study protocol, but useful for validation: one of the firemen (a team manager, reporting to the head of one of the regions) who was also present during the initial brainstorm independently made his own ad-hoc prioritization from the list of objectives as depicted in Table 2. His priority list was as follows (see Table 9, which also includes the target system definition priority for comparison):

Row no.	Priority according to team manager	English translation	Priority according to Target system definition method
1	1 (highest)	Uniformity of learning material between different regions	B
2	1	Uniform context for learning	C
3	1	Shared similar content between regions	B
4	1	Improved knowledge level by sharing knowledge between regions	B
5	1	Develop content by and for different regions	B
6	1	Country level learning process (instead of regional)	B
7	1	Firemen equally educated in different regions	n/a
8	1	More intensive cooperation with regard to life-long professional skills	B
9	2	Speed (learn quickly new learning material because of country wide developments in fire brigade)	C
10	2	Efficiency for organization regarding training	n/a

11	2	Efficient learning for firemen	A
12	2	Efficiency in firemen and means	n/a
13	3	Taylor-made training for firemen - learn what you need	A
14	3	Taylor-made learning style	n/a
15	3	Learning on basis of need & necessity	n/a
16	3	Reduce stress & strain for firemen	n/a
17	3	Learning what is needed not what is planned	A
18	3	More own responsibility (intrinsic motivation) for firemen for their own learning activities / learning process	n/a
19	4	Measurable level of professional skills	n/a
20	4	Effective learning leading to life-long professional skills	C
21	4	Quality of firemen´s skills demonstrably good	n/a
22	4	Quality in outcome	n/a
23	5	Flexibility in time and place of learning	n/a
24	5	Flexible learning for firemen	B
25	5	Place independent (Mobile!) learning so that firemen can learn time independent	C
26	6	Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved	A
27	6	Initial learning materials will be used for life-long learning	n/a
28	6	Staying professional / life-long learning more connected to initial learning	n/a
29	n/a	Nice & challenging learning environment	n/a
30	n/a	State of the Art learning environment	n/a
31	n/a	High quality learning material	n/a
32	n/a	Inspiring learning environment	n/a
33	n/a	Currentness of learning material	A

Table 9: Ad-hoc prioritization by fire brigade's team manager

The two prioritizations are quite different. Here are some explanations and observations as for these differences:
- Some differences can be explained by our explicit execution of step 2: the introduction of the objectives hierarchy and the combining of several objectives into one objective (see our above description on the execution of step 2). This concerns row numbers: 7, 10, 12, 14, 15, 16, 18, 19, 21, 22, 23, 27 and 28;
- As for row numbers 1 to 6 and 8: obviously the team manager rates the objectives categorized under 'cooperation' higher than the secretary. In a reflection the secretary stated that the team manager values regional development probably more than the secretary does. The secretary emphasized that striving for objectives directly related to the benefits for firemen themselves will increase the chance of success of the ELE implementation;
- As for row numbers 13 and 17: obviously the secretary values 'personalized learning' of higher importance than the team manager. See

also the argumentation in the previous bullet: reflecting on this, the secretary stated that the benefits related to the firemen themselves will increase the chance of success of the ELE implementation;
- As for row number 26, the team manager considers this objective as something that should be strived for by the country-wide organization, not by the 6 regions per se;
- As for row number 33: the team manager considers this as a constraint, in contrast to the secretary, who interprets this as a genuine objective;
- As for row number 9, in a reflection with the secretary, he mentions that currently country-wide developments are not easily agreed upon by the different fire brigade regions, and therefor he considers focus on quickly adopting those into an ELE as less important.

Degree of agreement regarding the two prioritizations relates to:
- Row numbers 29 to 32 are in both prioritizations 'n/a', as both the team manager and the secretary consider those not as objectives, but as constraints/requirements for the implementation of the ELE;
- One could interpret row numbers 11, 20, 24 and 25 as having a moderate to high degree of agreement.

The different prioritizations triggered the fire brigade of the 6 regions to carefully reconsider the prioritization, and make a final decision on what to strive for during the implementation of the ELE, and what to consider as less important.

Conclusions

With the validation of the first activity at the fire brigade we looked specifically at:
1. Can all steps of the first activity of the integrative framework be performed successfully?
2. Is the execution of the first activity of the integrative framework considered to be accurate?
3. Is the execution of the first activity of the integrative framework considered to be useful?

ad 1) The fire brigade case shows that indeed all steps can indeed be applied. Both the secretary and the team manager were involved in performing the steps 1-7 successfully.

ad 2) In a reflection the fire brigade's secretary states that he considers the model highly accurate, if applied following a robust procedure: he suggests to undertake step 3-5 with multiple employees, so that consensus on the resulting objective priorities can be made. This confirms the procedure as applied by Högler & Versendaal (2016), in which multiple user groups created multiple dependency matrices, which were consolidated in step 7 of the framework's first activity. In addition, as demonstrated at the fire brigade's validation, an extra ad-hoc prioritization helps in providing a reference for discussion on the prioritization through the dependency matrix.

ad 3) In relation to especially step 3-5 the remark of the secretary was that it was a "useful, yet extremely time-consuming execution; [...] it lets you focus on what is really of importance, but it costs a lot of effort. Yet at the same time I admit it is very useful: it will help during the actual execution of the implementation project for the ELE to concentrate on the really important things!". It shows that the creation of an objectives prioritization was expected not to take too much time; in our steps, however, it does take quite some time, especially when there are many objectives. What helps is determining the object hierarchy before (instead of 'in parallel') step 3, so that the dependency matrix is only consitst of process objectives (the lowest level objectives, that are drilled down from key objectives and basic objectives, see Table 7). Also presenting the dependency matrix in another format (e.g. as a list) may contribute to the speed with which values can be entered in the matrix.

We end with the statement of the secretary who mentions that "although creating the objectives prioritization through the dependency matrix was time-consuming, the investment at the start of the project (in defining thoroughly the target system) would definitely pay itself back during the execution of the actual ELE-implementation".

References

Ahlert, M. (2003). Einsatz des Analytic Hierarchy Process (AHP) zur Analyse von Wirkungsbeziehungen im Relationship Marketing. PhD thesis. Wiesbaden: Gabler.

Berghout, E., Nijland, M. and Powell, P. (2011): Management of lifecycle costs and benefits: Lessons from information systems practice. Computers in Industry. 62 (7), pp. 755-764.

Charette, R. N. (1991). The Risks with Risk Analysis. Communications of the ACM. 34(6), p. 106.

Corsten, H. (2000). Lexikon der Betriebswirtschaftslehre. München: Oldenbourg.

Drews, G. and Hillebrand, N. (2010). Lexikon der Projektmanagement-Methoden. Freiburg: Haufe.

Gadatsch, A. and Mayer, E. (2004). Grundkurs IT-Controlling: Grundlagen - Strategischer Stellenwert - Kosten- und Leistungsrechnung in der Praxis. Wiesbaden: Vieweg.

Gruhn, V. and Wellen, U. (2001). Process Landscaping: Modelling Distributed Processes and Proving Properties of Distributed Process Models. In: Unifying Petri Nets: Advances in Petri Nets. Ed. by Ehrig et al. Lecture Notes in Computer Science 2128. Berlin: Springer.

Heerink, D. (2014). Should health records go mobile? Exploring a mobile health record application in its support to process and quality improvement within

hospitals. Master thesis, Master of Business Informatics, Institute of Information and Computing Sciences, Utrecht University.

Högler, T. and Versendaal, J. (2016). Determining the Target System for Mobile Systems as Part of an Integrative Approach for the Economic Impact of ICS: Validation at an SME. 29th Bled eConference on Digital Economy, June 19-22, 2016, Bled, Slovenia.

Högler, T., Versendaal, J. and Batenburg, R. (2015). Evaluation of Mobile Systems – An Integrative Framework. Proceedings of the 21rst Americas Conference on Information Systems in Puerto Rico (AMCIS 2015).

Hwang, C. and Yoon, K. (1981). Multi Attribute Decision Making: Methods and Applications – A State of the Art Survey. Berlin: Springer.

Hway‐Boon, O. and Yu, C.M. (2003). Success factors in e‐channels: the Malaysian banking scenario. International Journal of Bank Marketing. 21 (6/7), pp. 369-377.

Iqbal, N., Nadeem, W. and Zahee, A. (2015). Impact of BPR critical success factors on inter-organizational functions: an empirical study. The Business & Management Review. 6 (1), pp. 152-165.

Kahneman, D. and Tversky A. (1979). Prospect theory: An analysis of decision under risk. Econometrica. 47 (2), pp. 263-291.

Kirchmer, M. (1999). Market- and Product-Oriented Design of Business Processes. In: Business Process Engineering – Advancing the State of the Art. Ed. by Elzinga, D.J., Gulledge, T. R. and C.-Y. Lee. New York: Springer, pp. 131-144.

Klabon, M.L. (2007). An Investigation of the Quantification of the Probability of Occurrence of Software Engineering Project Risks with Bayesian Probability. http://calhoun.nps.edu/bitstream/handle/10945/3121/07Dec_Klabon.pdf?sequence=1&isAllowed=y (visited 11/22/2015).

Köhler, A. and Gruhn, V. (2004). Mobile Process Landscaping am Beispiel von Vertriebsprozessen in der Assekuranz. In: Mobile Economy: Transaktionen, Prozesse, Anwendungen und Dienste. Proceedings of the 4. Workshop Mobile Commerce. Ed. by Pousttchi, K., Turowski, K. Bonn: Köllen, pp. 12-24.

Kronsteiner, R. and Thurnher, B. (2009). Opportunities and Risks for Mobile Decision Support. In: Handbook of Research on Mobile Multimedia. Ed-. by I. K. Ibrahim Hershey: IGI Global, pp. 93-104.

Kulk, G.P. and Verhoef, C. (2008). Quantifying requirements volatility effects. Science of Computer Programming. 72 (3), pp. 136-175.

Maimbo, H. & Pervan, G. (2005): Designing a case study protocol for application in IS research. In Chau, P. (ed.): Proceedings of the Ninth Pacic Asia Conference on Information Systems, Hong Kong, pp. 1281- 1292.

Meixner, O. and Haas R. (2012). Wissensmanagement und Entscheidungstheorie: Theorien, Methoden, Anwendungen und Fallbeispiele. Wien: Facultas.

NIST. (2012). Guide for Conducting Risk Assessments. National Institute of Standards and Technology (NIST). Special Publication 800-30. http://csrc.nist.gov/publications/nistpubs/800-30-rev1/sp800_30_r1.pdf (visited 01.03.2016).

Nysveen, H., Pedersen, P.E. and Skard, S.E.R. (2015). A review of mobile services research: Research gaps and suggestions for future research on mobile apps. SNF Working Paper No 01/15. http://brage.bibsys.no/xmlui/bitstream/handle/11250/279041/A01_15.pdf?sequence=1&isAllowed=y (visited 22.11.2015).

Rockart, J.F. (1979). Chief Executives Define Their Own Data Needs. Harvard Business Review. 57 (2), pp. 81-93.

Rückle, H. and Behn, M. (2007). Unternehmenserfolg mit Zielen. Renningen: Expert.

Saaty, T. L. (1996). Multicriteria Decision Making: The Analytic Hierarchy Process. RWS Publications, Pittsburgh.

Sing, M.P. and Vyas, R. (2012). Requirements Volatility in Software Development Process. International Journal of Soft Computing and Engineering. 2 (4), pp. 259-264.

Wild, M, and Herges, S. (2000). Total Cost of Ownership (TCO) – Ein Überblick. In: Arbeitspapiere WI, Nr. 1/2000. http://geb.uni-giessen.de/geb/volltexte/2004/1577/pdf/Apap_WI_2000_01.pdf (visited 11/22/2015).
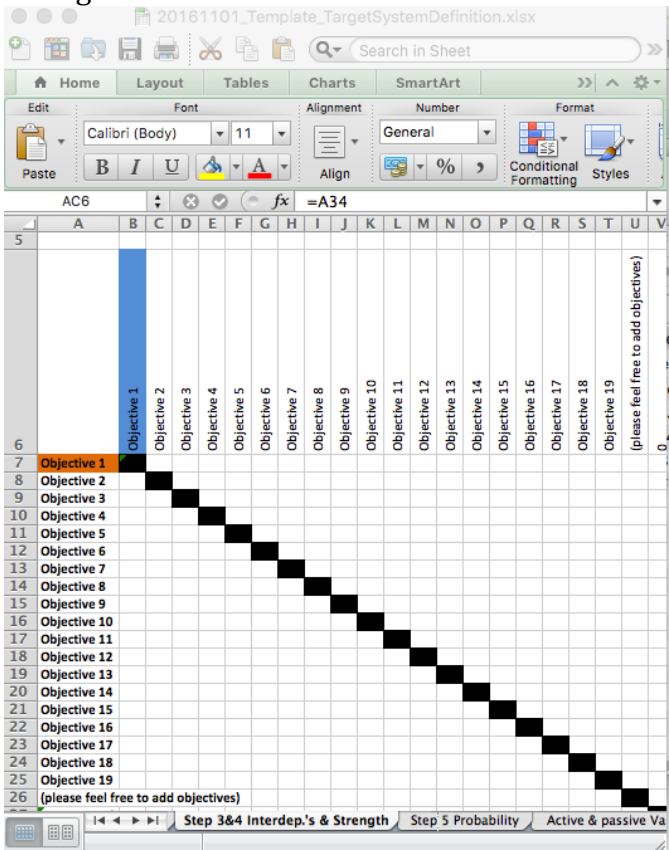
Technical Report

Appendix A - Template Excel-workbook for defining Target System Definition
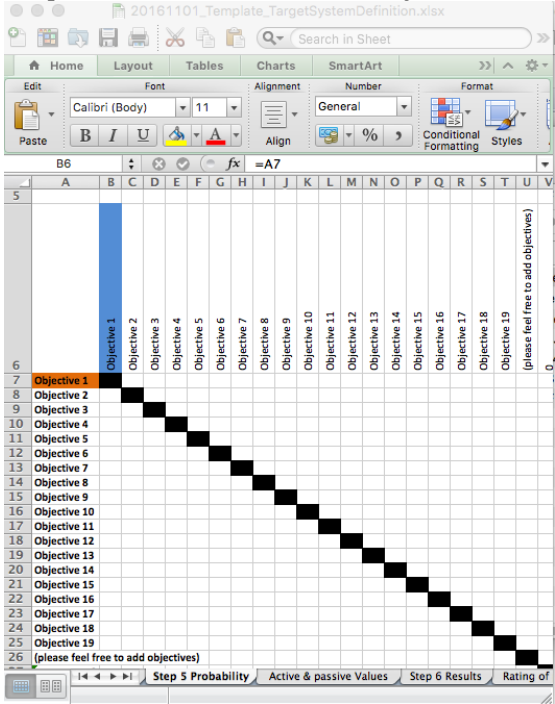Step 1: Determination of objectives
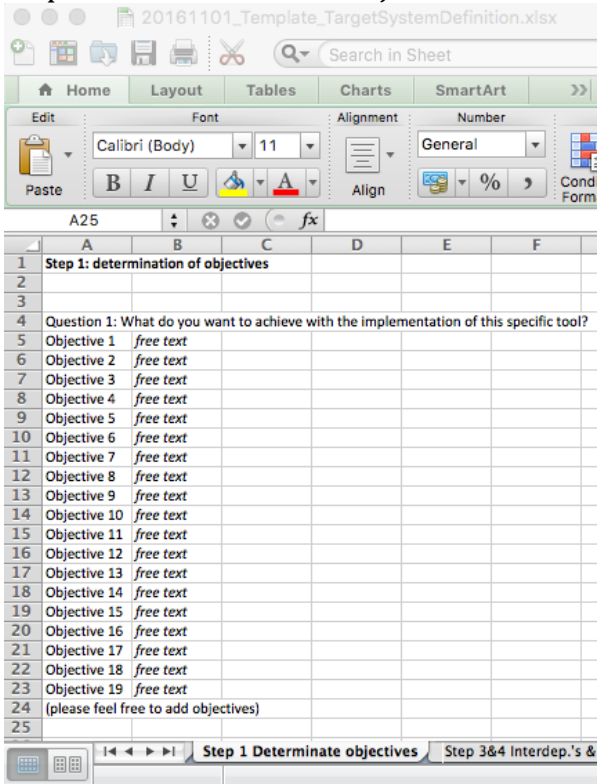
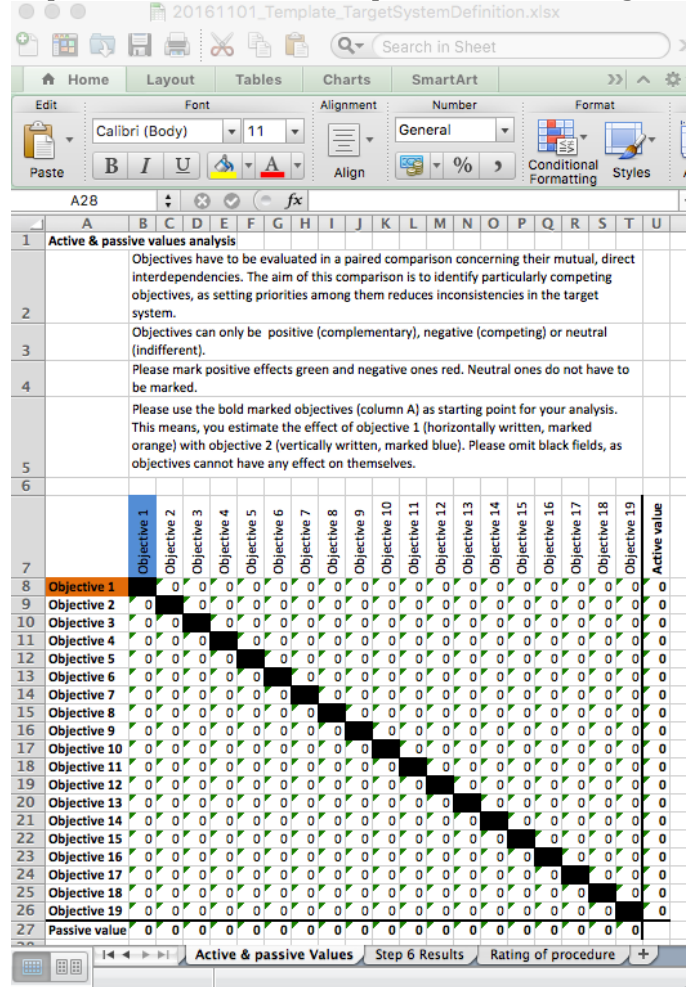Step 3&4: Determination of interdependencies (between objectives) and their strengths

Step 5: Determination of likelyhood of interdependencies between objectives

Step 6: Preference-neutral prioritization using active and passive values

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