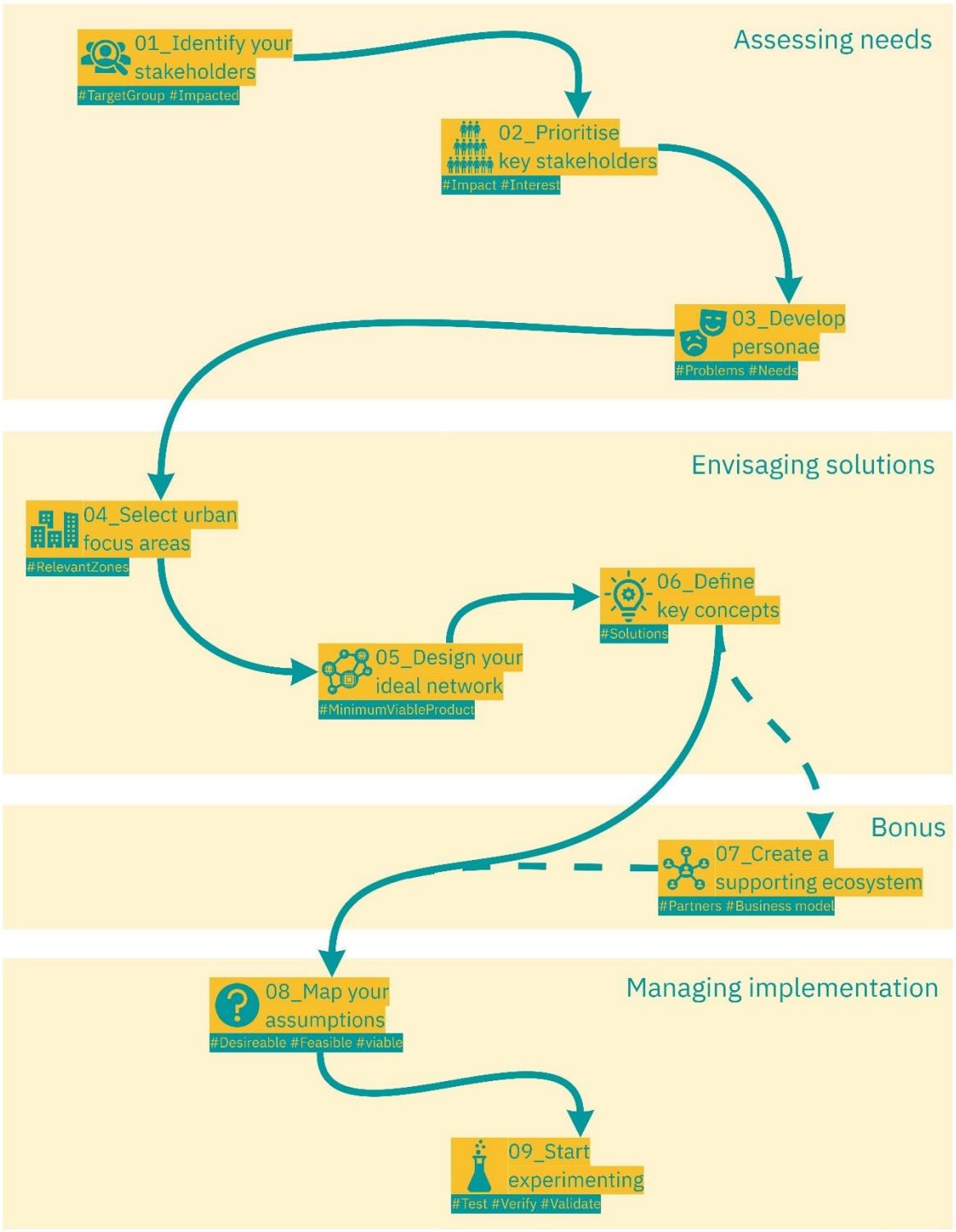
VAQUUMS

# Air Quality Sensor Roadmap



# 1 Introduction

## 1.1 Who is this for?

This roadmap is intended as a step-by-step guide for local authorities in planning an air quality sensor network. It can obviously also be used by any organisation supporting them in this development. Furthermore it will take into account any strategic considerations such as participation, scale, exposure …

## 1.2 How was this conceived and tested?

During the LIFE VAQUUMS project we had the opportunity to support 5 municipalities in Flanders taking their first steps in the field of air quality sensors. Early meeting had shown that the purpose of the sensor network(s) was too faint and had to be developed further. Previous experience had shown that broad, generic goals tend to lead to the conclusion that reference instruments are required.

We organised a 2-day workshop supported by innovation consultants and an air quality research institute. About 10 municipalities were joined in these workshops by citizens, experts and utility companies. The endpoint of these workshops were a number of potential applications ranging from school projects and dynamic traffic signs to the evaluation of measures. It also provided us with insights in the application of a design thinking process to the development of sensor networks.

The participating municipalities were unable to directly act upon the outcome of the workshops and we supported them further based on our expertise. At a later stage we were approached by the third largest city in Flanders to design an air quality sensor network for them. This opportunity allowed us to fine tune the workshop approach to result in an actionable outcome (overall project plan) for this city.

Our roadmap is the final approach that we were able to distil from this innovation track.

## 1.3 How to use this roadmap

The roadmap on the first page of this document is interactive, you can click it to quickly navigate to the relevant sections. At the top of each page you will see a map-button (  ) to go back to the roadmap.

Each section has the same hands-on setup:

- Aim of the activity: What should you try to accomplish? Why is this important? How will this carry over into the next step?
- Practical implementation: How have we done this successfully in our own workshops? What way of working do we recommend? The information here is basically a manual on how to organise a specific workshop or ideation session.
- Example(s): online tools you can use, including LIFE VAQUUMS' very own Miro templates to get you started right away. Miro is on online cooperative thinking platform

Some workshop methods will pop up in multiple sections, such as:

- Timeboxing: most brainstorming exercises rely on the notion of the 80/20-rule, meaning you'll come up with 80% of your ideas in 20% of the time. Although this is not a real scientific insight, the idea is it is not worth spending a lot of time to come up with the remaining 20%

of ideas, in particular as there are other participants who might have already thought of those.

- Hybrid brainstorming: a group brainstorm where everyone shouts there ideas might lead to less vocal participants not being heard, which risks leaving valid ideas undiscovered. On the other hand, individual brainstorms lack triggers by group dynamics etc. Hybrid brainstorming combines both methods. You will first spend some time brainstorming individually, followed by a session where individual ideas are shared and everyone tries to build on them. Typically using statements like "Yes, and …", "Yes, or also…, "Yes, that makes me think of …"
- Dot-voting: as you will generate many ideas, you will also have to prioritise them to keep things manageable (2.1 Purpose). A popular way of doing this is called dot-voting. In this process every participant is granted a number of votes (typically 3-5) which they can allocate to individual ideas by marking them with a dot. It is the moderators choice to allow whether a single participant can cast multiple votes on the same idea.



# 2 Purpose of this roadmap

## 2.1 Purpose

This roadmap provides a hands-on and trialed approach to get started with an air quality sensor network. As a user you'll be guided through 3 distinct journeys derived from the basic design thinking process.

- Assessing needs
  In line with our guidelines we recommend a high degree of specificity in the purpose of a sensor networks. This purpose is derived from good stakeholder and needs definitions. In 3 highly practical steps we guide you from an initial stakeholder inventory to "personae" reflecting archetypes of your key users.
- Envisaging solutions
  Based on a thorough needs assessment, this roadmap walks you through again three steps. You'll first select the most relevant zones in a city for the personae and needs at hand, which allows you in a next step to design both your ideal and minimal required sensor network. Lastly the roadmap will ask you to summarise conclusion is brief concept descriptions which will facilitate some of the next steps.
- Managing implementation
  Another clear recommendation in our guidelines is developing your sensor network through experimentation. Our workshops with European experts demonstrated that generalised instructions (e.g. on sensor quality, experimental design etc.) for specific applications (e.g. hot spot detection, policy evaluation …) were not feasible. Each implementation will require customization and a degree of trial and error. This journey will help you identify crucial assumptions that will make or break your network. You'll be able to define small scale experiments to validate your assumptions, reducing the cost of trials and the impact of errors. Finally, you'll be shown how to use this experiments and the information from the previous journeys to draft an implementation plan.

A common factor in all journeys is idea generation. At several points you'll hold some form of brainstorming activity which will give you many stakeholders, solutions, assumptions, experiments etc. which you could then elaborate over the ensuing steps. To keep this approach manageable, we

have included prioritisation steps (e.g. voting) to limit the number of ideas that flow into the next phase. Do not refrain from making this selection, it is worthwhile to first demonstrate your most valuable ideas work before adding others. Our basic approach – which ends in implementation through experiments and iterations – allows you to add the unused ideas in later stages.

Finally, we have included a bonus in this roadmap on a supporting ecosystem. The innovation experts we worked with provide an online toolkit which identifies value exchanges between all stakeholders. Mapping these exchanges will lead to insights in potential business models, contributions, added value etc.

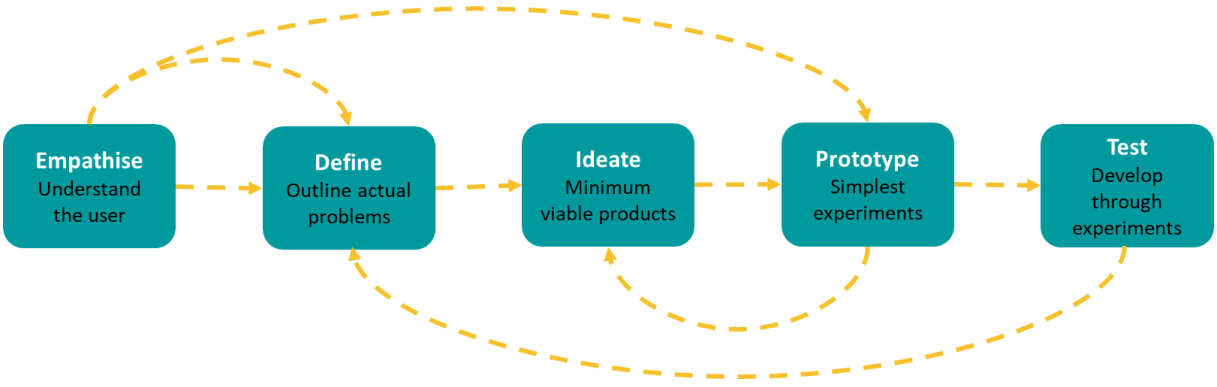
## 2.2 Guiding principles

### Design Thinking

The aforementioned journeys are based on the 5 stages of the design thinking process. This section of the roadmap briefly explains the design thinking process as background information. More elaborate description are readily available online and in literature.

In overview the 5 stages are:

- Empathise: try to imagine your stakeholders' context, problems and desires
- Define: summarise the information from the previous step into problem statements, reflected through personae/archetypes
- Ideate: come up with solutions for these personae, use the information you have to think outside of the box
- Prototype: develop – at a minimum cost – elements of your solution(s) that can be tested regarding their desirability, feasibility and viability
- Test: design simple experiments to (in)validate your prototypes, assumptions and then re-iterate




As is shown in the accompanying diagram, you can start iterating and revisit previous steps whenever you feel this is required. In this schematic we have already slightly changed the typical description of these steps to bring it in line with the inner workings of this roadmap.

### Lean startup

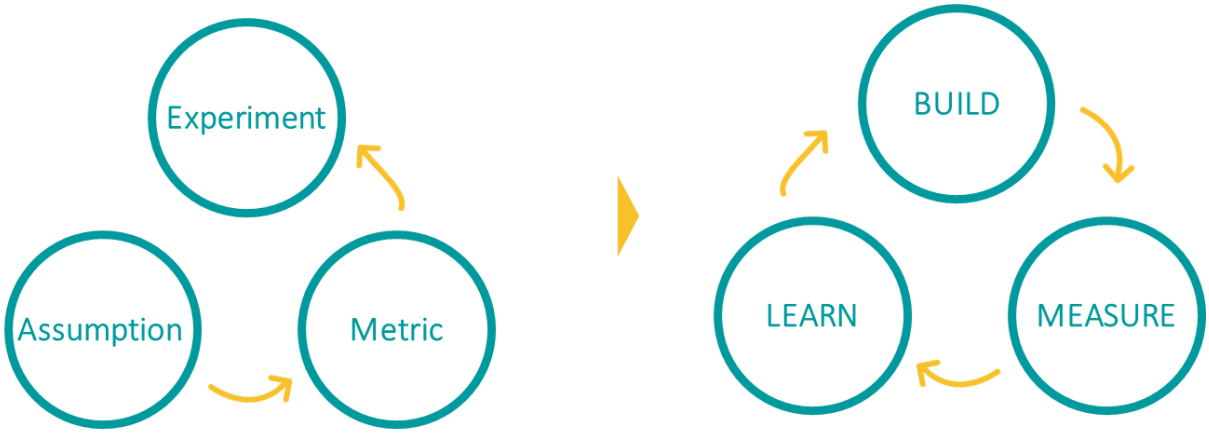
Traditional management methods are often unfit to handle the higher degree of uncertainty in an innovation context. Through the ideation steps in the Design Thinking process you will end up with many potential solutions. However the cost of developing any of them to then find they may not work is too high. Traditional management methods would also only allow you to assess success at

the end, once the product is complete. The Lean Startup method is centered on the idea to "think big, act small and fail fast (or cheap)".

The Lean Startup method applies 5 principles:

- Entrepreneurs are everywhere
- Entrepreneurship is management
- Innovation accounting
- Build-Measure-Learn
- Validated learning

The last two principles have been integrated in our roadmap. Our roadmap will help you in defining minimum viable products (MVP) and then designing the simplest of experiments to validate whether and MVP meets users' needs. We will do this by mapping assumptions for every MVP and defining metrics and experiments to validate those assumptions in the Build-Measure-Learn cycle.




By implementing this cycle in the implementation of your sensor network, you will be able to grow it through experimentation and iteratively adhere to the principle of validated learning.

# 3 First journey: assessing needs

Our first journey is focused on empathising with potential users of the air quality sensor network and other stakeholders involved. The final goal is drafting a set of typical problem or wish statements that you believe these users are facing.

## 3.1 Identify your stakeholders

### Aim

As you obviously first require an overview of all relevant stakeholders, this is our primary aim. Stakeholders in this step are not merely limited to (end-)users. We want to develop a good inventory here of everyone that could involved in an air quality sensor network. This will help in designing your solutions and implementation plan later on.

Based on our experience we distinguish 3 types of stakeholder:

- The target group – requires at least part of the concept of an air quality sensor network (or related tools) to accomplish his/her goal(s)
- The beneficiary – benefits from target group gaining access to the air quality sensor network (or related tools)
- The impacted – are confronted with results of the air quality sensor network and have to act on that

### Practical

Ready a number of post-its, perhaps with different colours for each participant, and a blank area for each of the stakeholder types.

We will apply hybrid brainstorming here. Depending on the experience of the group in generating ideas and the moderator, we recommend 5 to 10 minutes of individual brainstorming followed by 15 to 30 minutes of group discussion. Remember, always build on other ideas in a positive way “yes, …”.

---------- TIPS&TRICKS ----------

- The actual solution has not yet been defined, start thinking from the overarching concept of an air quality network including, tools, reports, webportals, but also distribution, maintenance etc.
- As (the need for) a sensor network is a hidden assumption, an even better approach might even be to think from merely an “air quality” theme. This allows you to challenge the necessity of a sensor network
- To help triggering ideas you could:
    - Do the inverse exercise: who is definitely not part of my target group?
    - Think of stakeholders in adjacent policy domains: could they benefit?
    - Think of impact in broad terms: who has to change his/her behaviour?

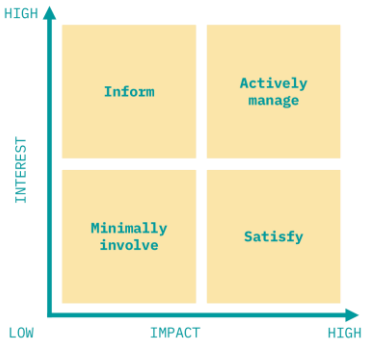
### Example(s)

- Templates in our downloadable pack

## 3.2 Prioritise key stakeholders

### Aim

Our aim is to select the stakeholder(group)s for which we will develop problem or wish statements. Not every stakeholder is equally relevant to your organisation and the overarching goal of an air quality sensor network. Their relative importance will define your approach, so we want to know which stakeholders have most impact (e.g. we will make the most adjustments to our solution for them) and which show most interest (e.g. will be most easily involved in the innovation process). This 2-dimensional assessment results in a distribution of stakeholders across 4 quadrants, defining how you should handle them.




- Actively manage: this group is most valuable in early innovation stages, they are both enthused by the sensor network as well as a determining factor for its setup. Actively work with this group and take their needs into account. They will aid development, serve as early adopters and contribute to the operationalisation
- Satisfy: this group will be difficult to involve but still is a determining factor for your success. A general recommendation is to grasp their needs and take this into account, while not actively involving them in the development. A working, validated solution should be provided to them in due time
- Inform: a less determining factor for success, yet eager to be involved. Actively involving them is a bit much as they have only a limited impact on your solution. You should keep them up-to-date on progress, releases etc. to maintain their enthusiasms and poll for any changes in attitude.
- Minimally involve: likely to have only a limited impact and not readily involved. Therefore we recommend leaving them at bay during the innovation process. Revisit this group once a solution is up an running to look for added value creation and fine-tuning.

### Practical

Provide a canvas with 2 axis and 4 quadrants as described in the aim. Use post-its from the previous session or copy them and distribute them across the canvas. Look for clustering, when stakeholders start forming a group on the canvas, and try to name this cluster when you feel they share needs. This limits the amount of stakeholders you carry over to the next step

It is important to note we consider 2 parameters:

- Impact: the impact of the stakeholder on the design, functionality etc. of the senor network, not the other way around! To what extent will you modify your solution to the needs of this stakeholder?
- Interest: the assumed, spontaneous interest in a sensor network and/or air quality. How easily do you think they can be involved in designing and testing a solution?

The advised method here is group discussion with a potential for individual preparation. Allocate stakeholders to participants and have them place them on the canvas. Allow them to explain their choice and facilitate a group discussion to fine tune the position on the canvas.

Based on our experience you will need 45 minutes to perform this entire step for 30 to 40 stakeholders.

Finally, perform dot voting to prioritise stakeholders. We recommend carrying over 1 to 3 stakeholders – usually from the 'actively manage' quadrant, sometimes 'satisfy' – for the next step, you can always revisit others in another iteration.

---------- TIPS&TRICKS ----------

- Provide discrete levels for each axis, e.g. 1 to 3, 1 to 5 or low, somewhat, medium, significant, high
- When distributing stakeholders, evaluate one axis first and then the other. This is easier than assessing the 2-dimensional position
- As a moderator, capture reasons why stakeholders are position high or low on an axis

### Example(s)

- Templates in our downloadable pack

## 3.3 Develop personae

### Aim

In this step you will analyse your stakeholders' motives, what they could gain from your solution and summarise those motives and gains in problem or wish statements. We focus on the stakeholders carried over from the previous step and characterise them through their:

- Negative motivation – frustrations, problems, fears
- Positive motivation – wishes, needs, dreams
- Goals – what are they trying to achieve? Why is that important to them?
- Context – how are these goals achieved today? What obstacles do they face?

You can then summarise the findings in a simple 2 component statement: "As [stakeholder], I have the problem that [problem] because of [driver]" or "As [stakeholder], I'd like to … so that I …". From now on we will call these stakeholders "persona(e)" as they become more archetypes and could also represent many potential individual stakeholders (e.g. different motives, similar goals etc.).

### Practical

You prepare a canvas with 6 blank areas for each stakeholder: the 4 characterisations above, an area to describe the persona and a quotes-area (see tips).

Participants usually have a good idea of these key stakeholders by now, so we would not recommend a complete hybrid brainstorming approach but it is not impossible. Normally a group exercise where participants talk freely about potential problems etc. and a moderator makes notes, suffices.

This approach will probably take you about 20-30 minutes for each persona.

Have participants look at the bigger picture and formulate key problem statements, use voting if you end up with much more than 3 per persona. Some detail may be lost in the statements but that often serves as a trigger for novel ideas when you envisage your solution(s). Furthermore you can always revisit a persona – highly recommended – at regular intervals.

---------- TIPS&TRICKS ----------

- Reach out to stakeholders at this point. We recommended having brief interviews, phone calls etc. to either feed or validate your analysis. You could for example get in touch with active citizens, the local climate council … Keep in mind though this is merely a qualitative

step. Quantitative user research is more time consuming and in a lean startup approach integrated in your experimental cycle (**2.2 Guiding principles**)

- Use quotes to make things tangible, these can be fictive or stem from the interviews. This will help empathising with your stakeholders
- Make the statements personal whenever you can

### Example(s)

- Templates in our downloadable pack

## 3.4 Concluding the assessing needs journey

Upon finishing this journey, you should end up with:

- A stakeholder inventory, distributed across 3 types
- A stakeholder map indicating a typical approach for each stakeholder
- A complete assessment of a persona's drivers and motivation
- A limited set of problem statements and personae to trigger ideation on solutions

Based on the problem statements – and perhaps on the envisaged solutions, as iteration is key – we would recommend to describe more specific ways of reaching out to stakeholders on your map. This can normally be done by the moderator/facilitator based on their understanding of the workshops. In our projects we have seen possibilities like:

- Use existing citizen networks
- Inform first, involve on case-by-case basis
- Co-ownership of the sensor network
- Focus on exchanging knowledge and information, rather than data

At this point it can also be useful to look at groups of problems that are faced across personae or stakeholders (e.g. more and better data, reduced duration of tasks …). Both these insights add value and can guide your implementation process, accompanying communication strategy etc.

# 4 Second journey: envisaging solutions

Our first journey brought us problems, wishes and goals that might be solved by an air quality sensor network. It is now time to define potential solutions by looking at relevant areas in a city and solution requirements. Finally we will summarise this in a number of key concepts that can be prototyped to assess our success.

---------- TIPS&TRICKS ----------

- For each exercise in this journey it is useful to have at least the problem statements for each persona at hand so they can be reviewed.

## 4.1 Select urban focus areas

### Aim

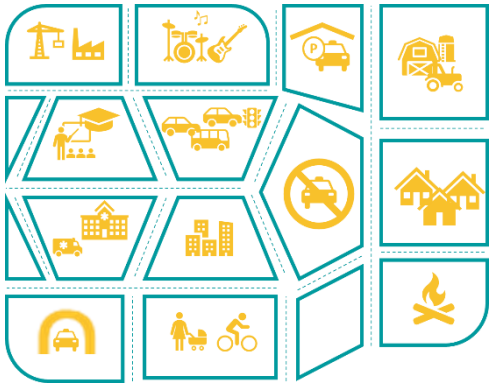
You managed to empathise with multiple stakeholders in the previous journey. In order to maximise idea output in this journey, we will "empathise" with the local context here. Our goal is to identify key areas in the city where a problem or need most often occurs. This will spur further ideation and also demonstrate where validation experiments are most useful (**5 Third journey: managing implementation**).

Typical zones we use are amongst others:

- Industrial zones
- Residential areas
- School districts
- Traffic intensive areas
- Agricultural zones
- Various zones of restricted access (e.g. pedestrian zones, low emission zones etc.)

### Practical

Create a large canvas representing building blocks in a fictional city for each persona. Use icons or words to identify certain interesting zones, but also leave some blocks blank. As a first step, ask participants to add a few types of zones in the city they feel are missing and relevant to the identified problems. Use the blank zones for this.



Use dot-voting to create a top 3 of most relevant zones for each persona. Write each top 3 zone on a post-it alongside the fictional city.

Apply hybrid brainstorming to think of real life zones and make the context more tangible, e.g. street names, school names, tourist attractions, parcs …

You should provide about 15-20 minutes to complete this for one persona.

---------- TIPS&TRICKS ----------

- If you feel all zones are relevant for a problem statement/persona, ask yourself this: "If you only have funding to implement a sensor network in one zone, where do you implement it to maximise satisfaction?"

- Do not forget that a zone outside the top 3 may still be relevant, it is just not our primary focus in designing a solution. It may be useful for the moderator to keep a complete ranking based on the dot-voting

### Example(s)

- Templates in our downloadable pack

## 4.2 Design your ideal network

### Aim

You will now start thinking of solutions to the identified problems. We will distinguish between the minimum requirements of a sensor network and the optimal configuration. The parameters we use to configure a sensor network are:

- Pollutants to be monitored
- Accuracy, either as a hard parameter or qualitative (e.g. peak detection, hot spot, WHO assessment …)
- Temporal resolution of the reported data
- Extent to which data is available in realtime
- Number of sensor locations
- Other parameters to be monitored

In our project we have seen that it suffices to define a network at the level of a persona rather than a problem statement. This step can take quite some time and will spark many discussions. It is therefore highly recommended to also capture the specific use cases that will be mentioned that would e.g. require higher or lower accuracy.

---------- TIPS&TRICKS ----------

- This step in our roadmap has been specifically designed for air quality sensor networks. If you feel there are other potential solutions to the identified problems, host a more general ideation session and proceed to the next steps. The next steps should – with some imagination – still be easily applied to other ideas than sensor networks.

### Practical

You will need at least a blank canvas for the pollutants and other parameters to be monitored. Temporal resolution, realtime level and number of locations can be defined on a pre-set scale. Your approach regarding accuracy will depend on the level of proficiency of the participants, we typically defined some qualitative descriptions of a quality level upfront. Do not forget to implement a configuration of both the minimal and optimal sensor network (have a look at our templates in the examples section).

Discussions on accuracy, temporal resolution, realtime level and number of sensors will yield many detailed use cases or solutions. We recommend having a blank low, medium and high area for each of these parameters.

We recommend some form of hybrid brainstorming here where (small teams of) participants each configure a sensor network for a specific persona. The group discussions are used to validate this analysis and discuss specific solutions, opinions etc. Invite participants to write down every solution that is mentioned on a post-it in the blank low, medium or high areas, complete this as well while moderating discussions.

Total duration can be quite long here, likely at least 1 hour for the preparation and discussion of one configuration.

---------- TIPS&TRICKS ----------

- We recommend having a look at our template to better understand this exercise
- It is often easier to define minimal and optimal configuration for one parameter and then move on to the next instead of first the entire minimal configuration
- It helps to also have the top 3 zones and the specific local street names etc. at hand to help imagine possibilities
- If you are limited in time, you could do only a single optimal configuration as these can tend to be similar across personae. Do mind that you will lose some insights and potential solutions this way

### Example(s)

- Templates in our downloadable pack

## 4.3 Define key concepts

### Aim

At this point you should have discussed many potential solutions and network properties. To keep things manageable, you will now summarise these insight into a limited number of key concepts. A key concept links problem statements, solutions and desired outcomes at the persona level. We recommend using a standardised statement, like "For [stakeholder] facing the problem of [problem] because [driver], we offer a [solution] with the following key properties [properties]. This solution will work because [outcome]."

As you can see this links all work that has been done in the first two journeys of our roadmap.

### Practical

Prepare a blank canvas for the [solution], [properties] and [outcome] attributes of the above standard statement. Provide an overview for each persona containing the relevant zones in a city and problem statements. Make sure participants can revisit the network configurations from the previous step.

Use hybrid brainstorming here by asking participants to formulate – in easy wording – potential solutions for each of the problem statements. Depending on the amount of statements you can assign just one or multiple participants to each statement. In the second part of the hybrid brainstorm focus on adding new ideas and [properties] to the existing ideas.

Perform dot-voting here to limit either the number of solutions or the personae to carry over.

This exercise should be relatively brief and take about 10 minutes of individual and 20 minutes of group brainstorming.

---------- TIPS&TRICKS ----------

- [solution] can just be a short name or one sentence description
- Create added value by listing the use cases or solutions from the previous step that are related to the key concepts you define here. This will save some time in preparing the implementation timeline

Example(s)

- Templates in our downloadable pack

## 4.4 Concluding the envisaging solutions journey

Upon finishing this journey, you should end up with:

- A prioritised list of all potentially relevant zones in the city, both per persona and overall
- A high level sensor network configuration for each persona and/or problem statement
- A number of potential use cases or solutions linked to (1) persona(e) and (2) low, medium or high requirements for certain parameters

To add value and prepare for the next steps, the moderators can delve a bit deeper in the information collected. We recommend drafting a table summarising the potential use cases and links to persona(e) and parameters as in the example below.

| | Persona(e) | Accuracy | Temporal res. | Realtime level | Scale (# sensors) |
|---|---|---|---|---|---|
| Wood smoke peak detection | Environmental manager | Medium | High (1s - 1m) | Realtime | High (>20) |

The full table can then be prioritised according to Accuracy>temporal resolution>realtime level>Scale. In our experiments we considered accuracy and temporal resolution as determining factors for difficulty of implementation and used a combined index for ranking. This ranking will help in determining implementation order etc.

| Index | Accuracy | Temporal resolution |
|---|---|---|
| 1 | LOW | LOW |
| 2 | LOW | MEDIUM |
| 3 | LOW | HIGH |
| 4 | MEDIUM | LOW |
| 5 | MEDIUM | MEDIUM |
| 6 | MEDIUM | HIGH |
| 7 | HIGH | LOW |
| 8 | HIGH | MEDIUM |
| 9 | HIGH | HIGH |

# 5 Third journey: managing implementation

## 5.1 Map your assumptions

### Aim

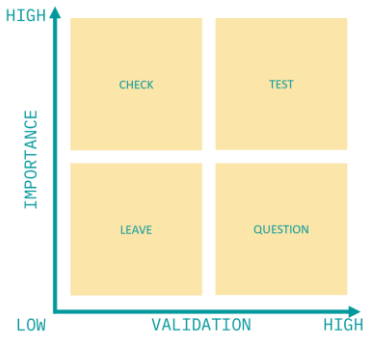
You now have a ranked list of potential solutions targeting stakeholders facing a number of problems. Along the way you have made many assumptions which can be broadly categorised as:

- Desirability – user oriented: is this really what your stakeholders want?
- Feasibility – solution oriented: can we actually do this?
- Viability – market oriented: should we actually do this?

To determine whether these assumptions were valid we will first identify them by revisiting our previous work. We will also start working on our assumption validation strategy by mapping assumptions based on their importance and the ease of validation: How important is an assumption? E.g. low importance is wen a solution would still work if an assumption turned out to be invalid. How readily can we validate it? E.g. information on the assumption is unknown, also externally and would require more work to validate.

Similarly to the stakeholder mapping exercise this will lead to 4 quadrants:

- Check – high importance, fairly easy to validate – also called 'requirements' or 'just do' as you could just demand e.g. a third party to comply in a tender – should be checked for validation through e.g. literature survey, manufacturer website etc.
- Test – high importance, more difficult to validate – requires experimentation, prototyping etc. to validate
- Question – lower importance, more difficult to validate – try and obtain this information externally, e.g. through questionnaires etc.
- Leave – lower importance, fairly easy to validate – leave this for the time being




### Practical

Prepare a triple blank canvas to brainstorm assumptions for desirability, feasibility and viability. Also prepare a canvas with 2 axis and 4 quadrants as described in the aim. Use post-its from the previous session or copy them and distribute them across the canvas.

Organise a hybrid brainstorming session identifying underlying assumptions you have made regarding desirability, feasibility and viability of potential solutions. In a next step, again using hybrid brainstorming, ask participants to move post-its from the triple canvas to a position reflecting their importance and ease of validation on the 4 quadrants. We recommend assigning a subset of post-its, e.g. 1 of the 3 aspects, to each participant rather than assigning a full persona. The latter would result in longer discussions over the exact placement in the quadrant system.

In our experience the assumption inventory should take 30 minutes to complete (20 minutes individual, 10 minutes group). The mapping exercise will likely take 15 minutes and another 10 for discussions.

---------- TIPS&TRICKS ----------

- You can perhaps reuse your triple canvas template from the stakeholder identification (**3.1**)
- You can also boost this exercise by first asking participants to write down key aspects of solutions targeting a specific persona with respect to the user (who was this for?), solution (most important aspects of a sensor network, use cases) and market (who can contribute? How do we finance this? (see also **6 Bonus quest: designing an ecosystem**))
- Questions to trigger desirability assumptions:
    - Why would this work
    - Why would the user change their current way of working?
    - Wat does a user do with your solution? What do they want to achieve?
    - Why can a user not do this without your solution?
- Questions to trigger feasibility assumptions:
    - What technological challenge are there in realising this solution?
    - What internal challenges are there?
    - Why will your management support this solution?
    - What skills do you need?
- Questions to trigger viability assumptions:
    - How will you reach your user?
    - Why will they keep using your solution?
    - Why will they recommend it to others?
    - How is this solution being financed?
- Provide discrete levels for each axis, e.g. 1 to 3, 1 to 5 or low, somewhat, medium, significant, high
- When distributing assumptions, evaluate one axis first and then the other. This is easier than assessing the 2-dimensional position
- As a moderator, capture reasons why assumptions are position high or low on an axis

### Example(s)

- Templates in our downloadable pack

## 5.2 Start experimenting

### Aim

One of the most important guidelines of LIFE VAQUUMS is developing your sensor network through experimentation. We will use the assumptions from our previous step to guide us to useful experiments to kick start an air quality sensor network.

Focus on assumptions that had a higher difficulty of validation, e.g. labelled as ‘test’ or ‘question’. The assumptions labelled as ‘check’ should be kept on a ToDo-list and worked on as soon as appropriate.

To validate an assumption you will define potential metrics and whenever possible a level qualifying the assumption as validated (e.g. higher than 10µg/m³, or 80% of respondents …). Secondly describe the simplest experiment possible to obtain a value for the metric and validate the assumption.

### Practical

List all assumptions stemming from the previous step and provide a blank canvas for metrics and experiments.

Apply hybrid brainstorm by assigning clusters of assumptions to individual participants and asking them to first think of potential metrics and then experiments to measure those. Follow-up this up by a group discussion adding metrics, experimental details etc.

The timing here is highly dependent on the amount of assumptions and expertise of the participants. Based on our experiment we would expect 10 minutes of individual brainstorming followed by 20 minutes of group discussion in a group of 4 participants assessing about 40 assumptions.

---------- TIPS&TRICKS ----------

- Prior to this step, try to cluster assumptions based on common aspects like user interface, data architecture, quality etc. This will help designing experiments in a certain domain
- If you have a limited number of use cases or solutions at the end of journey 2 (max. 5), you could perform this step directly for each solution instead of for each persona. This will help later on in  Templates in our downloadable pack
- Concluding the managing implementation journey
- An added step could be to include a 'ToDo' canvas describing steps that have to be undertaken to complete a certain experiment
- Focus on the shortest route to validate an assumption rather than setting up the scientifically most interesting experiment

### Example(s)

- Templates in our downloadable pack

## 5.3 Concluding the managing implementation journey

Upon finishing this journey, you should end up with:

- An inventory of assumptions
- An assumption map indicating how you should validate these assumptions
- A list of the quickest and easiest experiments to validate the most challenging assumptions

At this point 2 steps remain to set up an implementation plan. Firstly summarise the work in the third journey by looking for clusters in the assumptions linked to personae, e.g. what categories of assumption do you observe for a specific persona. In our projects we identified categories such as:

- Skill level and available time
- Fit for purpose
- Financing
- Data standardisation
- Related data products
- Involvement
- Ease of use

Also draft a table linking persona, assumption and experiments as in the example below.

| | Persona | Domain | Assumption | Metric | Experiment |
|---|---|---|---|---|---|
| #1 | Environmental manager | Desirability | Sensor network is sufficiently dense to answer questions | Max. amount of sensors/km² suffices to answer 50% of questions in last 3 years | Map public questions of last 3 years and compare this to network resolution and density |

### Linking all aspects into an implementation timeline

We have a number of experiments now to kick-start your senor network. To perform a first prioritisation of experiments, you should link them to the use cases or solutions which have already been ranked at the end of the second journey.

- Create a matrix with all assumptions or assumption-experiment combinations on one axis and use cases on the other. Mark links between assumptions and use cases with an 'x'. Assumptions have been drafted for each persona so this can help guide you.
- Some assumptions might be relevant for all use cases (overall) or should clearly be validated as a first step (prerequisite). Put these on a separate list.
- Based on the difficulty index of the corresponding use cases, assign a minimum and maximum difficulty score to each assumption as in the table below.

| | Assumption | Cat.* | Linked use case(s) | Min. | Max. |
|---|---|---|---|---|---|
| #1 | Sensor network is sufficiently dense to answer questions | P | ▪ Complaint handling | 4 | 4 |

*categories: O=Overall, P=Prerequisite, R=Regular

Similarly, we can now prioritise our key concepts (**4.3**) as in the next step these will guide you in creating logical stages. To do so, we will create a matrix linking key concepts to use cases.

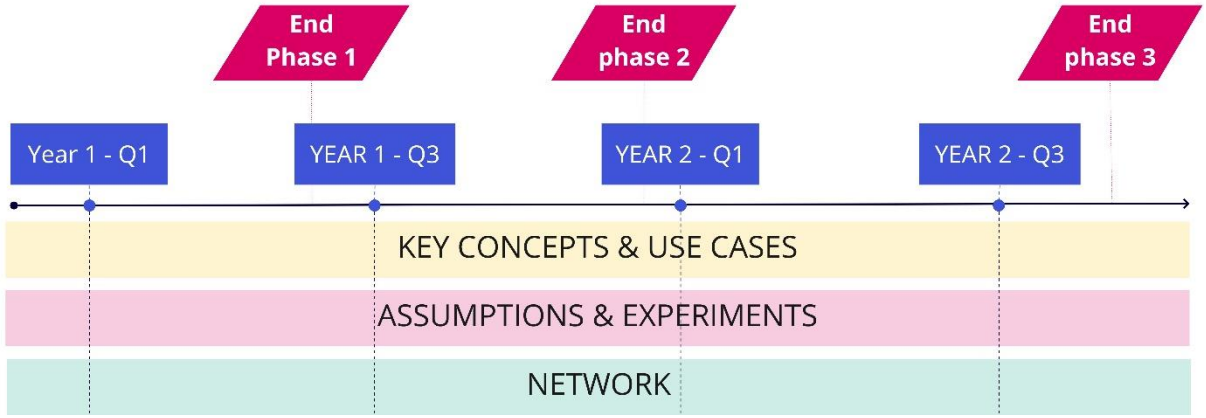
- Have you done the added value exercise and linked use cases to key concepts in **4.3**? Great! If not, create a matrix for each persona linking key concepts – these should contain a [solution] and [problem or need] – to use cases or solutions (**4.2**). This should be fairly easy as the concepts summarise findings on the use cases, sensor network and relevant zones.
- You can now create a table assessing the difficulty of each concept, as in the example below

| Key concept | Need | Linked use case(s) | Min | Max |
|---|---|---|---|---|
| Urban air quality dashboard | Centralised urban air quality data | ▪ General AQ indicator<br>▪ Yearly report | 1 | 3 |

As a next step you need to distinguish relevant phases or stages in the implementation. We will use the key concepts (**4.3**) for that. Distinguishing phases may require some creative thinking as it depends entirely on the output of all previous steps.

- All or a subset of the overall and/or prerequisite assumptions should make up a logical first stage. That's your preparation stage.
- Try to group the key concepts (**4.3**) into logical stages. Also look into the difficulty level and linked use cases, some use cases will be linked to multiple concepts guiding you to logical stages.
- As an example, we distinguished the phases below in one of our projects.

You should now be able to populate each stage with use cases, assumptions and experiments linked to the key concepts, creating an overall timeline as in the example below.




That's it! We hope you found this roadmap useful in guiding you to an implementation plan – through experimentation – of a user-oriented air quality sensor network.

# 6 Bonus quest: designing an ecosystem

## Aim

In your first journey you focused on your stakeholders, we then continued working mainly on the target group or potential users. However one of the other stakeholder categories was beneficiaries, they benefit from a sensor network implementation without being a direct user. Additionally there are stakeholders that can improve or support the sensor network.

It is worthwhile considering potential roles of this beneficiaries and supporting stakeholders in a sensor network implementation. The aim is to identify opportunities for shared burden, co-creation, co-financing etc. to reduce risk for an individual municipality. We'll do this by drafting an ecosystem and indicating the value exchanges between the relevant stakeholders. This will help laying the groundwork on who you should involve early on in the implementation of your sensor network.

This roadmap has been developed through iterative improvements of a workshop first drafted by Board of Innovation. This step is an unmodified creation of them and provided through a free-to-use template on www.miro.com.

## Practical

Setup the required workspaces in Miro using the Board of Innovation template.

Group participants 2-by-2 to design the ecosystem on a specific key concept (**4.3**) and have them:

- Naming and placing the relevant stakeholders
- Identifying and drawing value exchanges
- Challenging one-way exchanges by brainstorming an value exchange the other way around (e.g. urban sensor network provides data to health researchers, but was does the city gain in return?)

Anticipate on providing at least 30 min. of time including 10 minutes for pitching and group discussion

---------- TIPS&TRICKS ----------

- You can get started by placing one of the relevant stakeholders on the board and asking questions like:
  - What does this stakeholder receiver from the solution?
  - By whom is the stakeholder offered the solution?
  - What does the stakeholder offer in return?
- Challenge yourself by removing a key stakeholder, can you find a workaround?

## Example(s)

- Board of Innovation Miro-template 'The Business model kit'

# 7 Acknowledgements

This roadmap has been developed through iterative improvements of a workshop first drafted by Board of Innovation and the Flemish Institute for Technological Development (VITO). The LIFE VAQUUMS consortium is grateful for guiding us through the first workshops and introducing us to the design thinking principles.

Board of Innovation provides many other innovation tools freely through their website www.boardofinnovation.com.