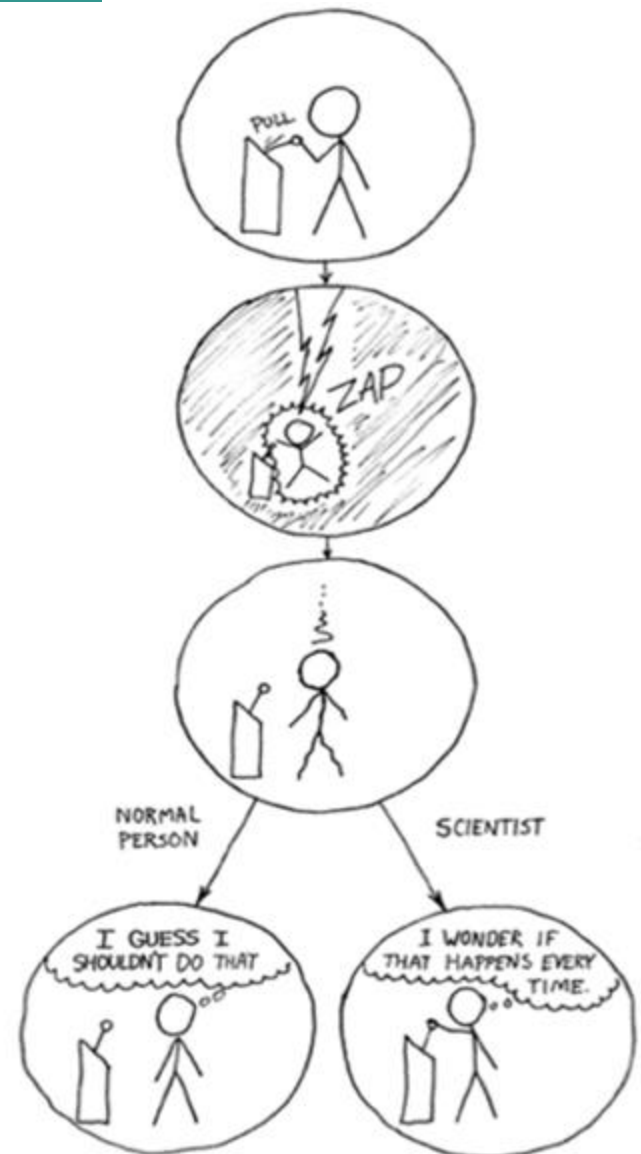


# The experimental process

Ivano Malavolta



# Question from the previous edition

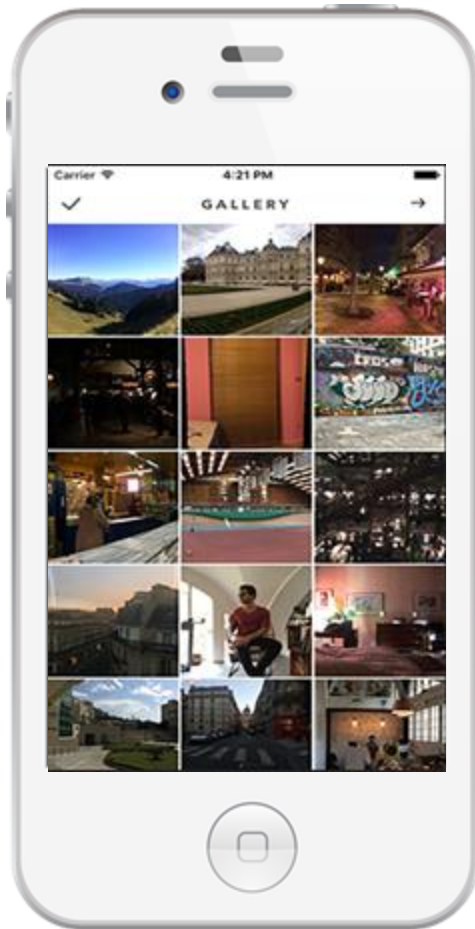
What exactly you want from the assignment?



## Answer

- Show that you are getting familiar with the problem
- Give an indication about what you want to achieve with the experiment
- Show that you know how to structure the definition of an experiment according to the GQM
- Show that you are able to phrase quantifiable research questions according to measurable metrics
- Show that you did your homework in studying related literature
- See examples of Assignments on Canvas

# Running example



**Image encoding:** how do image encoding algorithms impact the energy consumption of a mobile app?

- PNG
- JPEG
- ...

# Roadmap

Experiment principles

Terminology

The experimental process

# Experiment principles

# Empirical software engineering

Scientific use of quantitative and qualitative data to

- understand and
- improve

software products and software development processes

[Victor Basili]

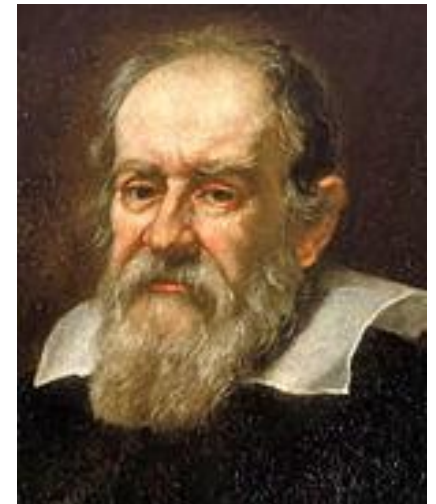
**Data** is central to address any research question

Issues related to **validity** and **replicability** addressed continuously

# Intuition

It is an application of the **scientific method**

- ask yourself a *question*
- background *research*
- formulate an *hypothesis*
- setup an *experiment*
- observe *phenomenon*
- perform *analysis* on your results
- draw *conclusions*



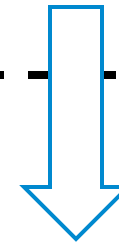
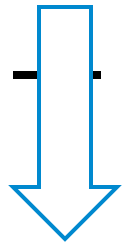
# Experiment principles

## Theory



If I use different image encoding algorithms...

... different energy efficiency



JPEG, PNG

measured energy consumption per app

## Observation



# Terminology

# Terminology

- **Independent variables**: quantities that we are able to manipulate/control (a.k.a. *input* variables)
  - e.g. encoding algorithm, size of image, operating system
- **Dependent variables**: quantities observed in the study (a.k.a. *response*, *output* variables)
  - e.g. energy consumption, gallery loading time

# Terminology

- **Factor**: an independent variable that we deliberately manipulate/control
  - e.g. image encoding algorithm
- **Treatment**: a specific value of a factor
  - JPEG, PNG for the image encoding algorithm
  - 1, 10, ..., 100 for the number of images in the gallery

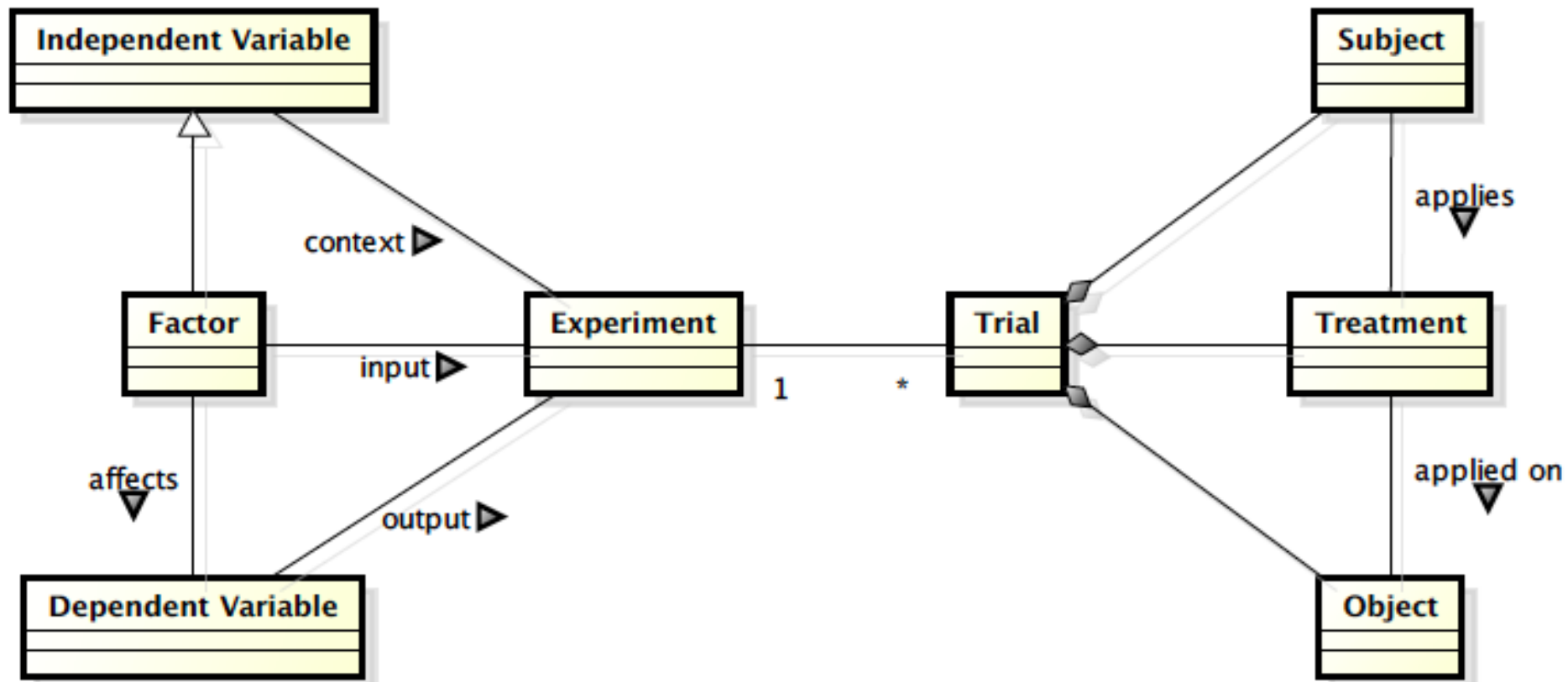
# Terminology

- **Subject:** who applies the treatment
  - e.g. software developer, software architect, user
- **Object:** the receiver of the treatment
  - e.g. image galleries of Android mobile apps

# Terminology

- **Trial**: combination of **subject**, **object** and **treatment**
  - e.g. **developer** John develops **app X** that encodes images using the **JPEG** algorithm
- **Experiment**: a combination of several **trials** to observe the effects of the **treatments**
  - e.g. ???

# Let's put them all together...



Version 1.2  
© Marco Torchiano, 2014



# The experimental process

# 0 - It all starts with an idea

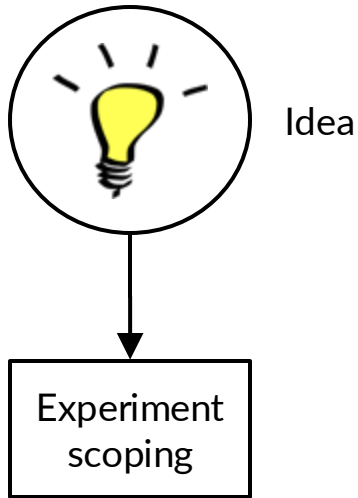


Idea

- Main idea behind the experiment
- The hypotheses must be stated clearly
  - Not formally, just clearly

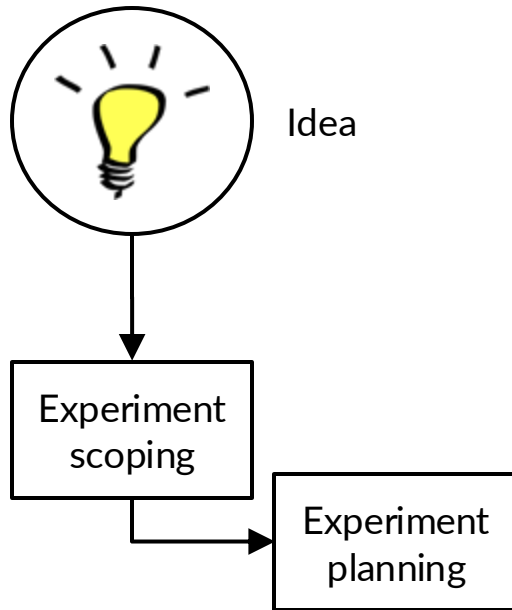


# 1 - Experiment scoping



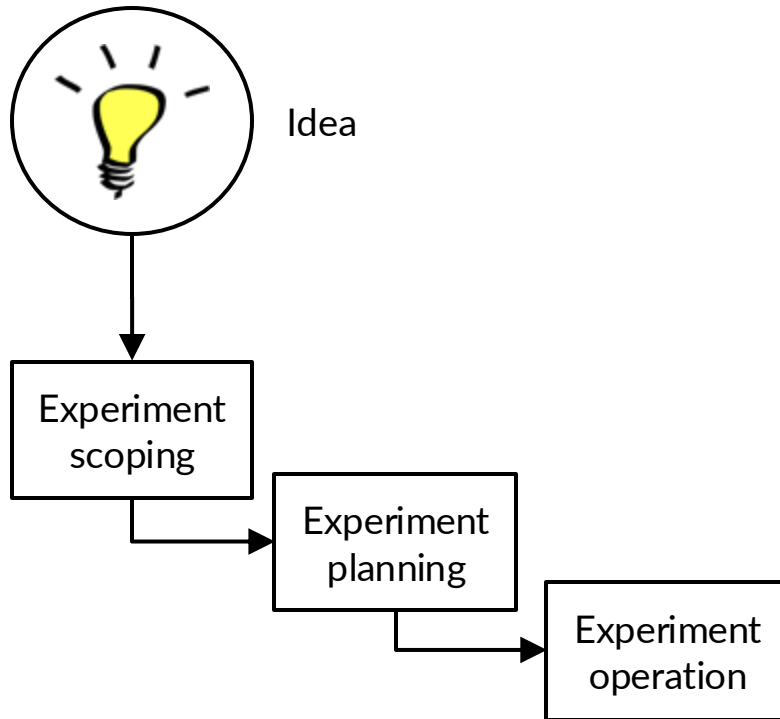
- We scope the experiment by stating the problem, objectives, and goals
- We will use the Goal-Question-Metric (**GQM**) framework

## 2 - Experiment planning



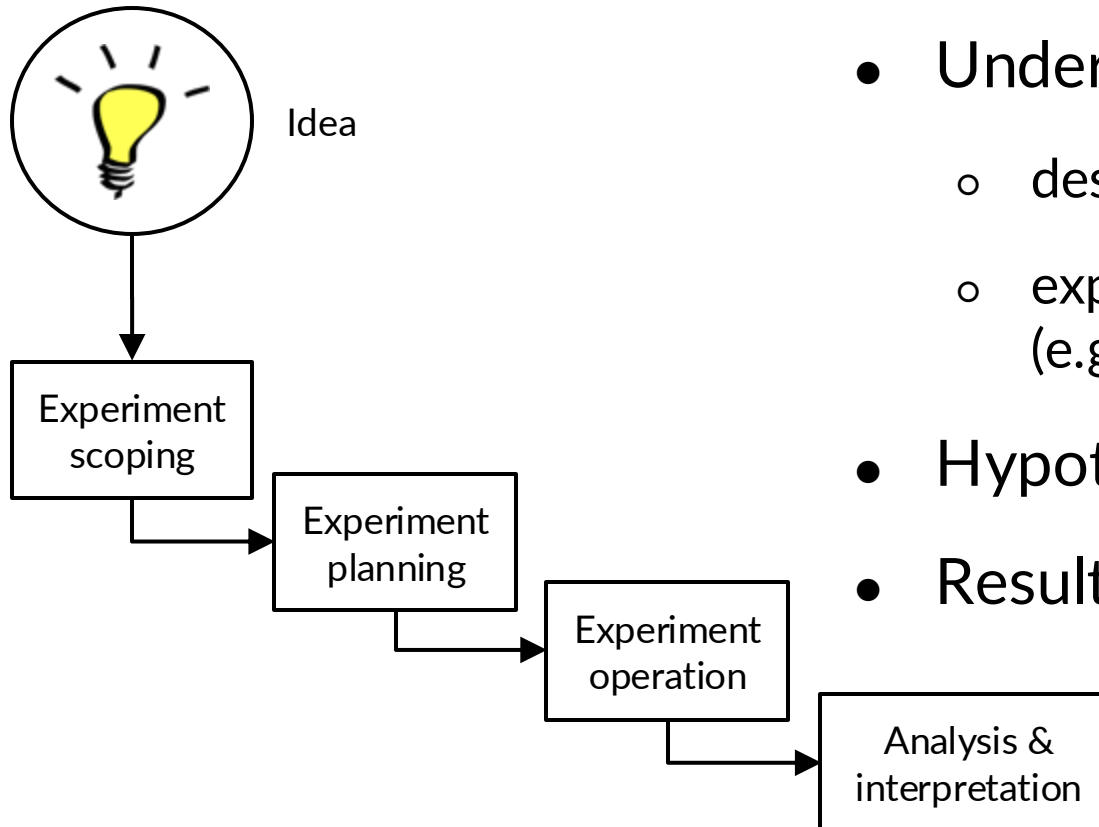
- Define context
- Formulate hypotheses
- Identify input and output variables
- Design the study
- Instrumentation
- Analyze validity threats

# 3 - Experiment operation



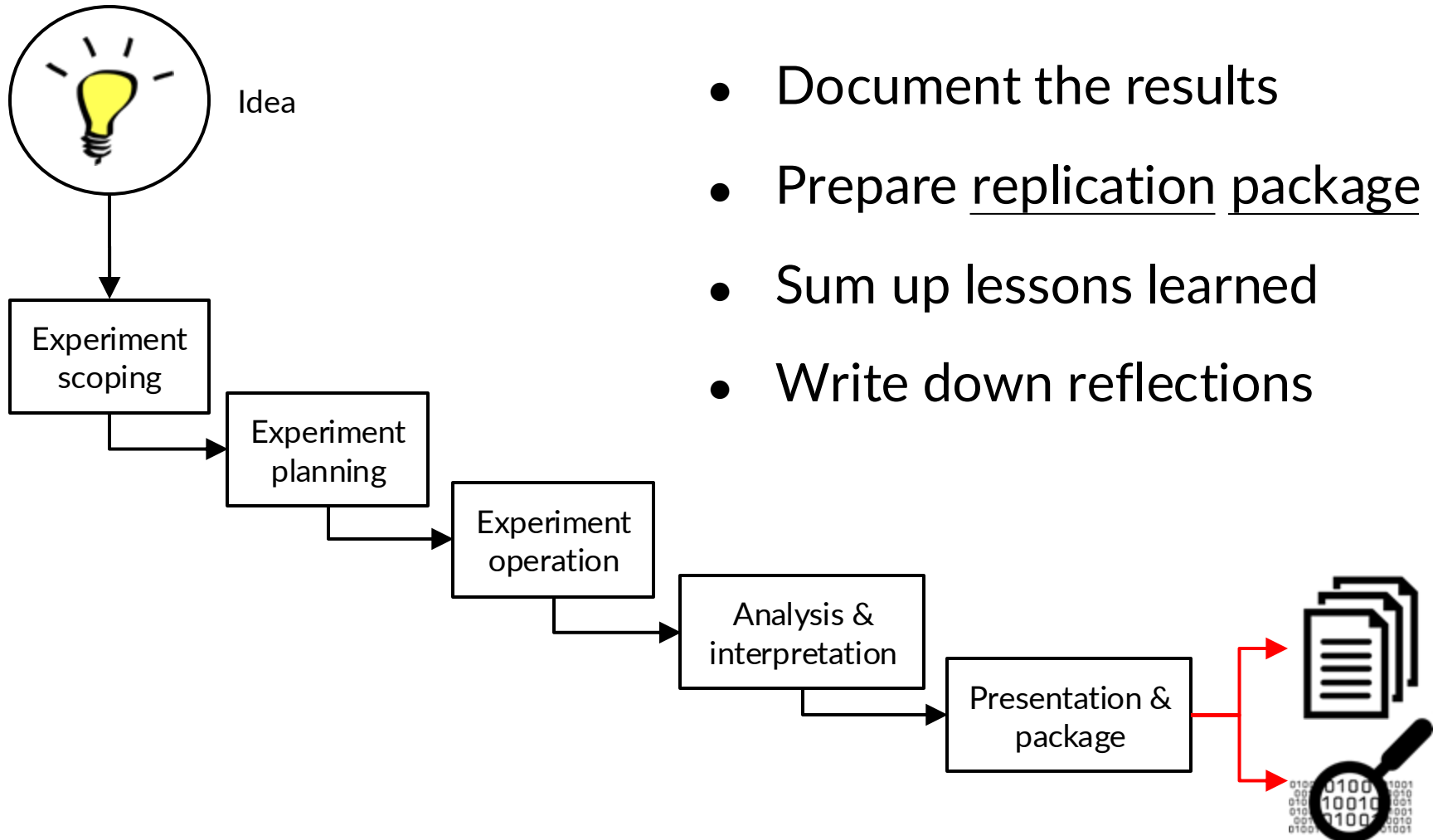
- Preparation
  - Guidelines, subjects training, code instrumentation, ...
- Execution
  - aka measurements collection
- Data Validation

# 4 - Analysis & interpretation



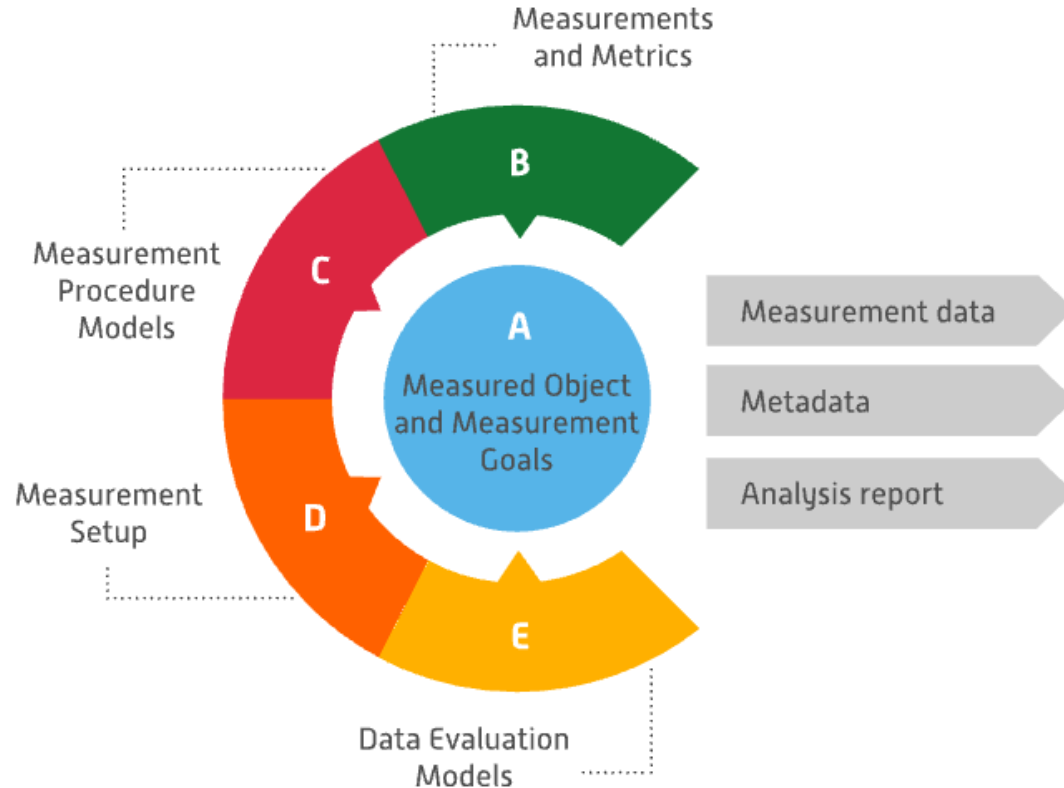
- Understanding the data
  - descriptive statistics
  - exploratory data analysis (e.g. box plots, scatter plots, ...)
- Hypothesis testing
- Results interpretation

# 5 - Presentation & package



# The Green Software Measurement Model (GSMM)

A framework that contains essential elements for measuring the the environmental impact of software

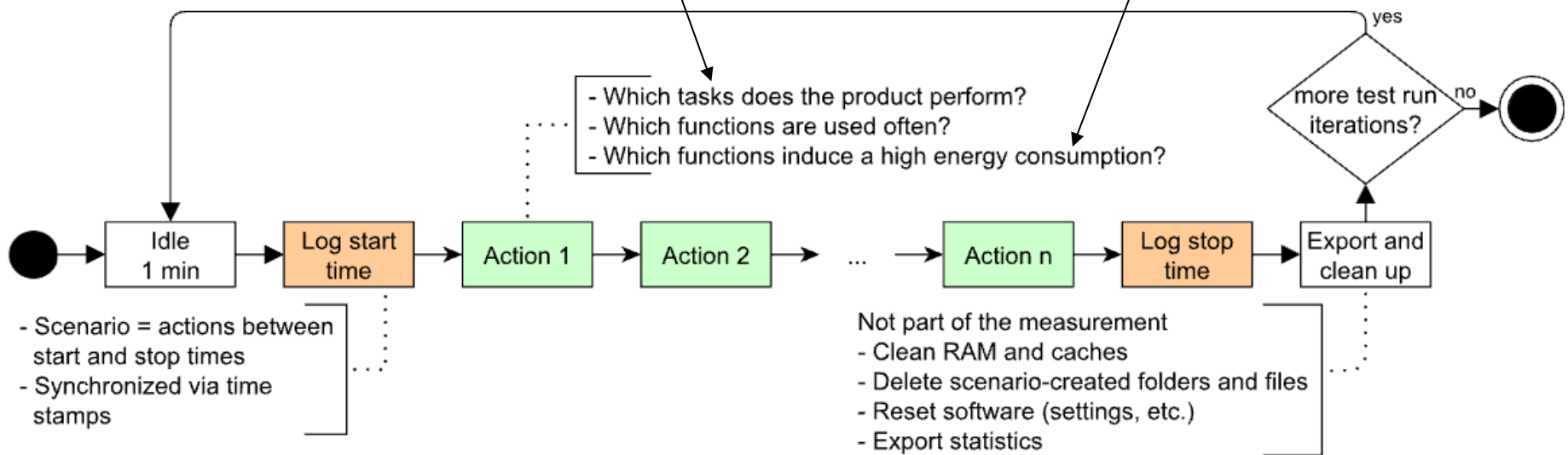


# Anatomy of an experimental run

## Types of scenarios:

- Idle
- Standard usage
- Different load scenarios
- Baseline

## White-box VS Black-box measurement



# What this module means to you?

- You have the basics on experimentation **principles** and **terminology**
  - Theory VS observation
  - Variables, treatments, factors, ...
- Overview of the experimental **process**
  - It is not a pure waterfall model
    - > But after operation you cannot come back!



# Readings



Chapter 6

[https://www.ivanomalavolta.com/files/papers/FGCS\\_2024.pdf](https://www.ivanomalavolta.com/files/papers/FGCS_2024.pdf) (Sections 5 and 6.3.2)