# Systems Engineering Research Methods

by *Gerrit Muller*     University of South-Eastern Norway-NISE

e-mail: `gaudisite@gmail.com`
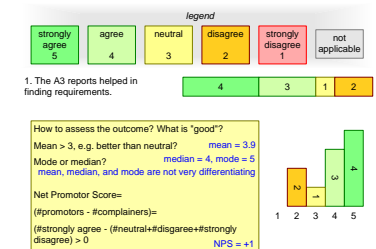
`www.gaudisite.nl`

## Abstract

Research in System Engineering research inherently addresses a mix of technological issues in relation to business, process, organization, and people aspects. We show an inventory of research methods for research done in the "field", e.g. in industry or similar organization.
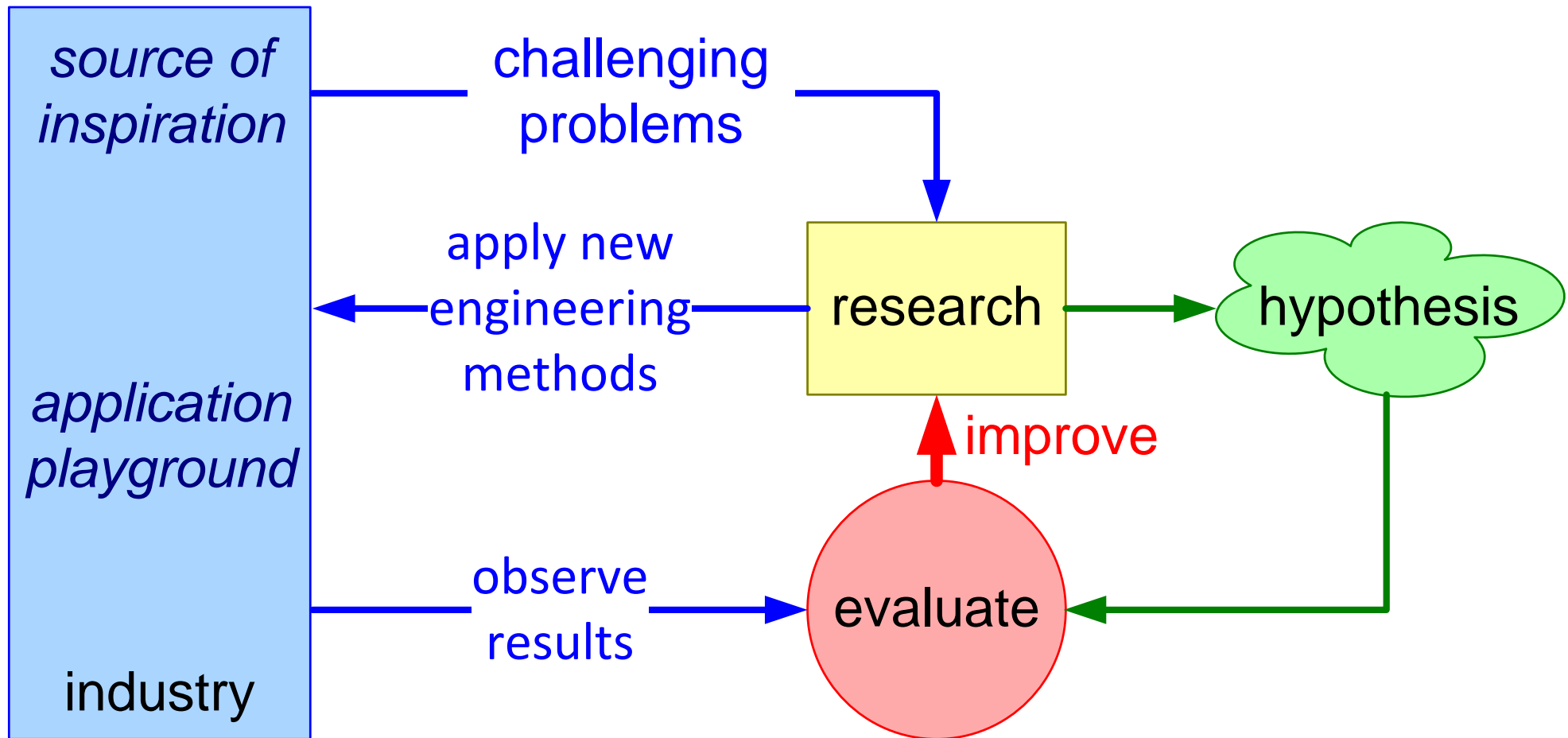
August 21, 2020
status:     preliminary draft
version: 0.2

# Action Research or Industry-as-Laboratory

# Systems Engineer vs Researchers

| | *systems engineer* | *researcher* |
|---|---|---|
| normal work | elicit needs, specify, design, analyze, integrate, test | observe, experiment, argue, evaluate, write |
| attitude | explain, educate, sell | question everything, proof opposite |

USN  ESI

# Logical Order of Research
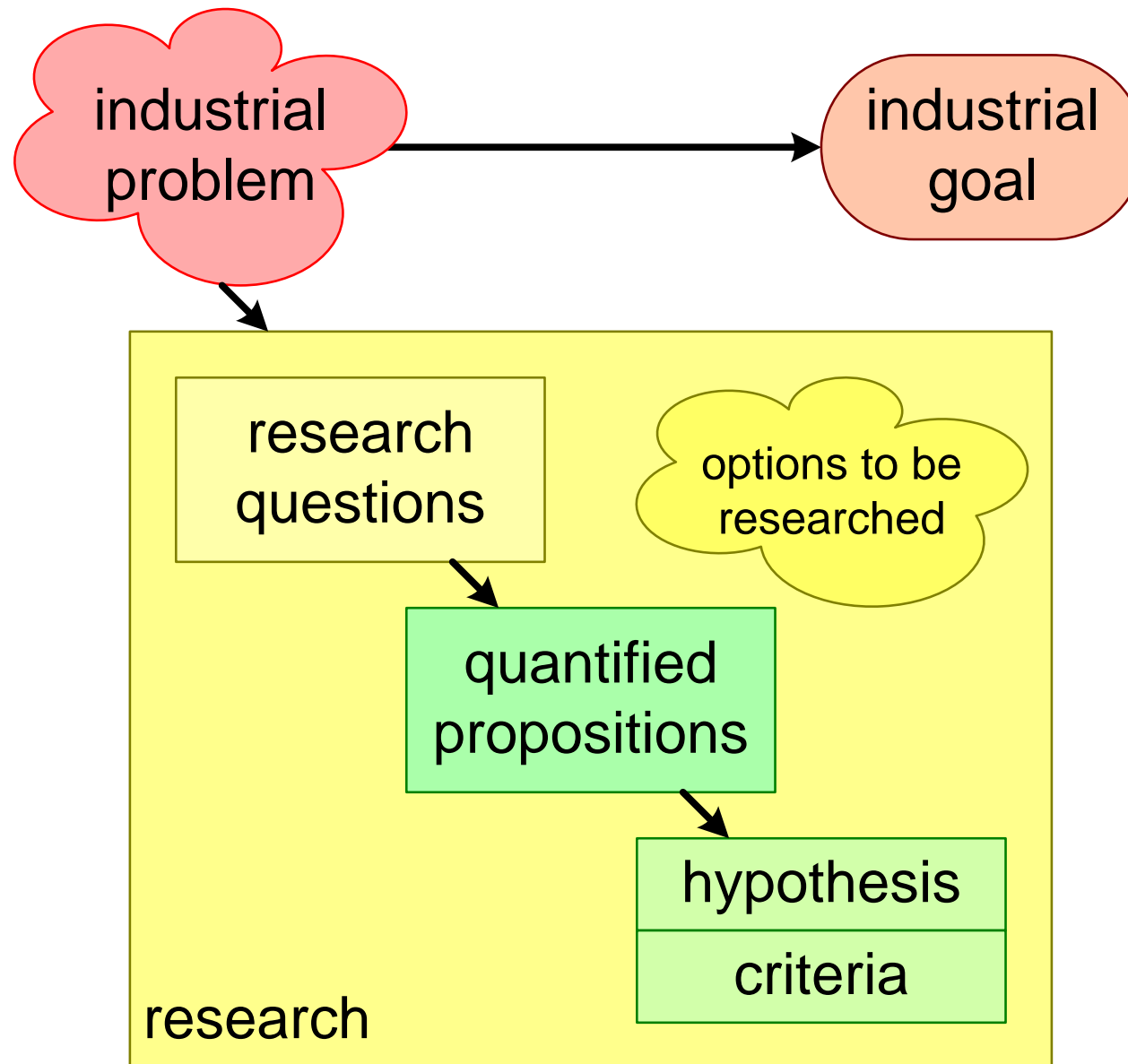
# Simplified Order for Master Project
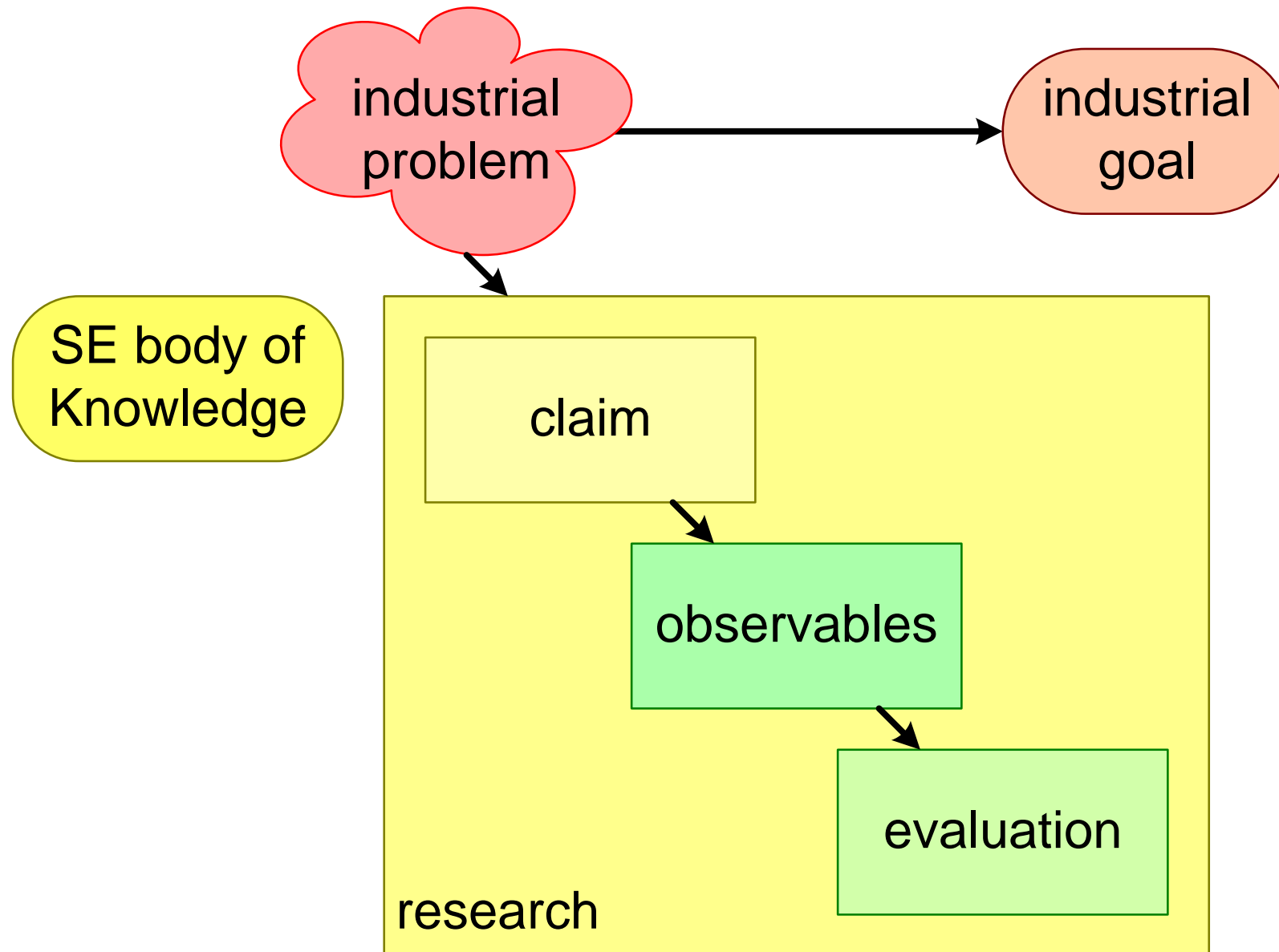
# Step 1: Formulate Claim

Claim: What benefits will your proposed improvements bring?

"Application of requirements traceability matrix
will reduce changes after the definition phase significantly"

20% or 80%
would be better

Be specific (what, who, when, how much, ...)

Does the claim address the original problem?

Is the claim realistic?

Do the benefits justify the research effort?

Do the benefits relate to the right driver?

better predictability of delivery
earlier delivery
better quality of delivery
less cost or effort

# Step 2: Identify Observables

> **Observables: What observations or measurements will provide evidence for your claim?**
>
> number of changes <small>after definition phase</small> in past projects without method
>
> number of changes <small>after definition phase</small> in current project with method

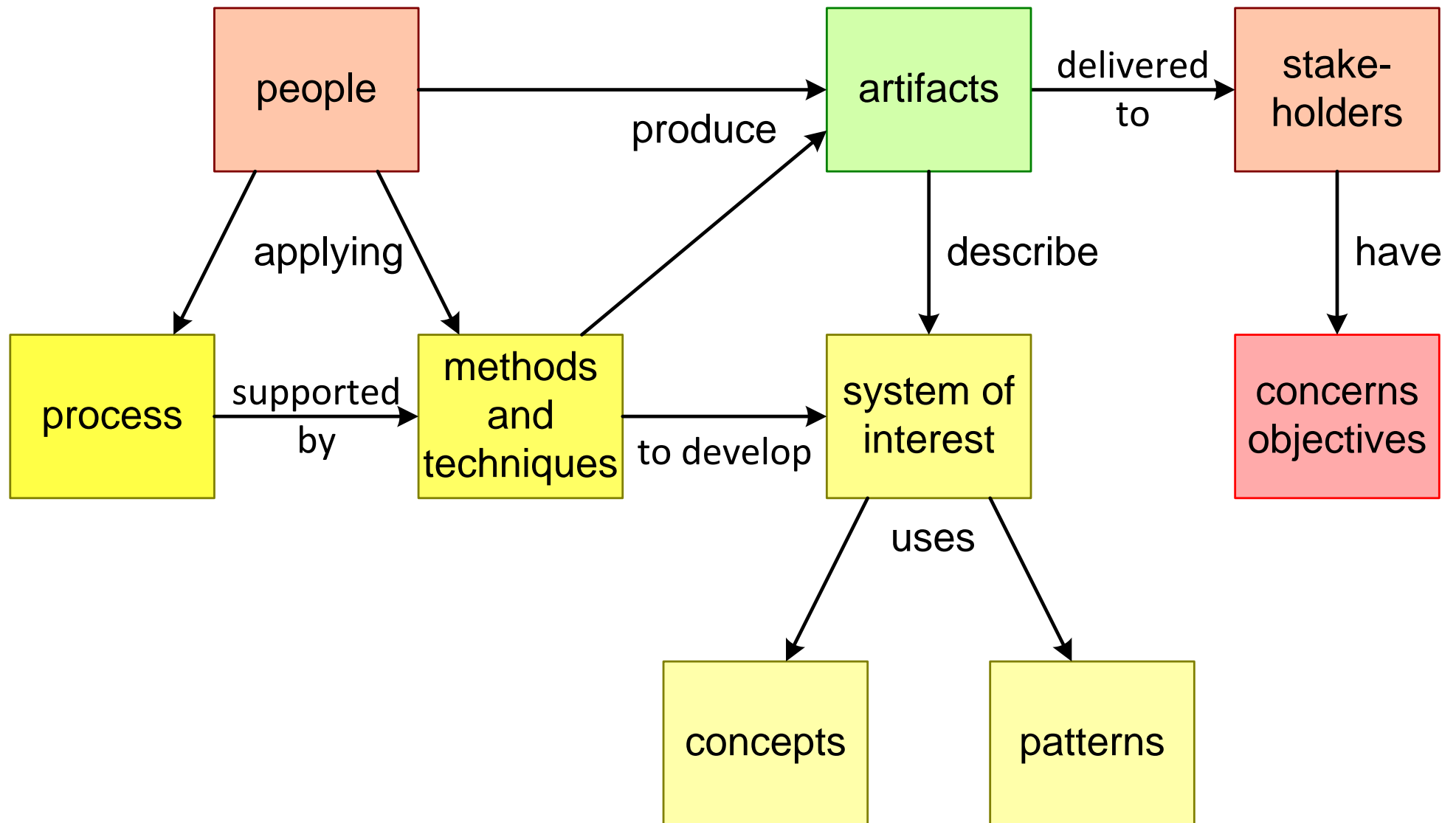Be specific (what, who, when, how much, ...)

Do the observations relate to the claim?

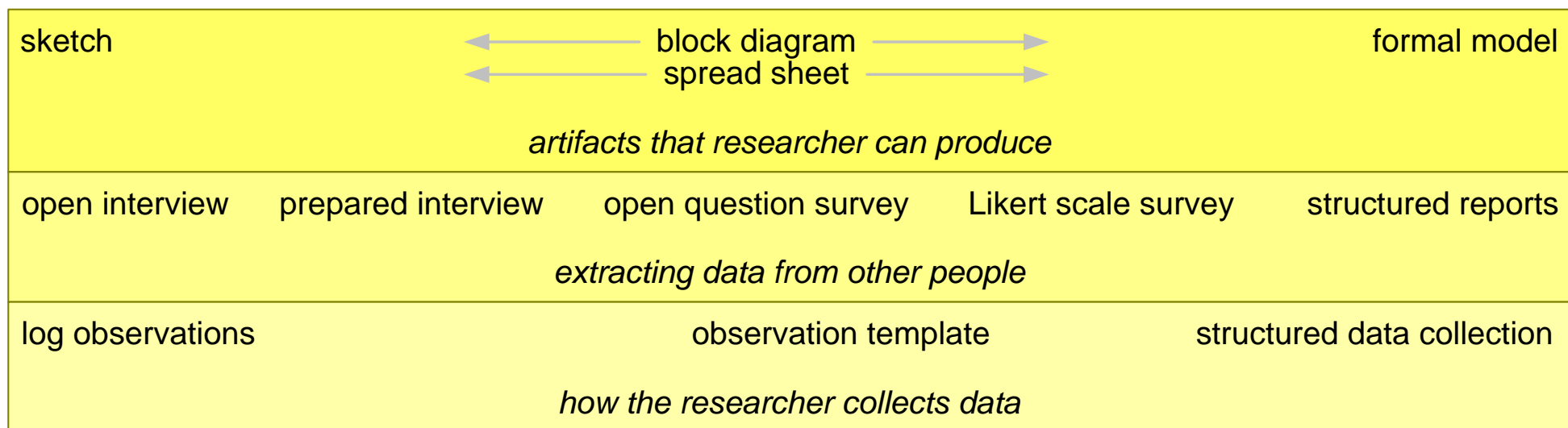Can the observations be made during the research period?

How accurate and objective are the observations?

Observe/measure the initial state before changing "zero measurement"

USN  ESI

# What to Research; Observe Context

# Spectra of Research Methods

| | | | | |
|---|---|---|---|---|
| sketch | ← block diagram → | | | formal model |
| | ← spread sheet → | | | |
| | *artifacts that researcher can produce* | | | |
| open interview | prepared interview | open question survey | Likert scale survey | structured reports |
| | *extracting data from other people* | | | |
| log observations | | observation template | | structured data collection |
| | *how the researcher collects data* | | | |

←— free format                                           standardized format —→

. free representation                          . standardized data
. no formal definition                         . formalized definition
+ supports                                     + supports
    discovery                                        analysis
    exploration                                      comparison
- difficult for                                    aggregation
    analysis                              - might
    comparison                                 restrict inputs
    aggregation                                affect observation

USN   ESI

# Research Logbook

Word or PowerPoint file

take notes continuously!


date/time

    what

    how

    why

    when

    where

    who

references, e.g. URLs; make electronic copy of any relevant material

all "raw" data, e.g. submitted questionnaires

all intermediate data, e.g. spread sheets with version numbers and dates

# Example Observation Template

| Session attributes – date (year/month/day) | | |
|---|---|---|
| **Kind of session:** | | Communicate information/status |
| | | Sell a idea/concept |
| | | Brainstorming/generate ideas |
| | | Decision making |
| | | Solve/discuss problem(s)/issue(s) |
| | | Planning |
| | | KPI/Performance/Action log |
| | | Team building/training |
| | | Presentation |
| **Physical location of session:** | | Defined meeting room |
| | | Colleague own office |
| | | In the factory – "on the shop floor" |
| **Planned session or not:** | | Planned |
| | | Unplanned |
| **A3 purpose:** | | |
| **A3 name/link:** | | |
| **A3 usage/iteration number:** | | |
| **A3 usage time with stakeholders:** | | |
| **Number of participants:** | | |
| **Did everyone understand the A3:** | | |
| **Did it answer some of the stakeholders questions:** | | |
| **Create any new questions/concerns:** | | |
| **Models changed/added:** | | |
| **Stakeholder participation:** | | |
| **Prefer A3 instead of A4:** | | |
| **Observations/recordings:** | | |

from Master Project by Espen Polanscak

USN    ESI

# Survey with Likert Scale

## Questionnaire

|  | strongly agree | agree | neutral | disagree | strongly disagree |  | not applicable |
|---|---|---|---|---|---|---|---|
| 1. The A3 reports helped in finding requirements. |  |  |  |  |  |  |  |

## Presentation data
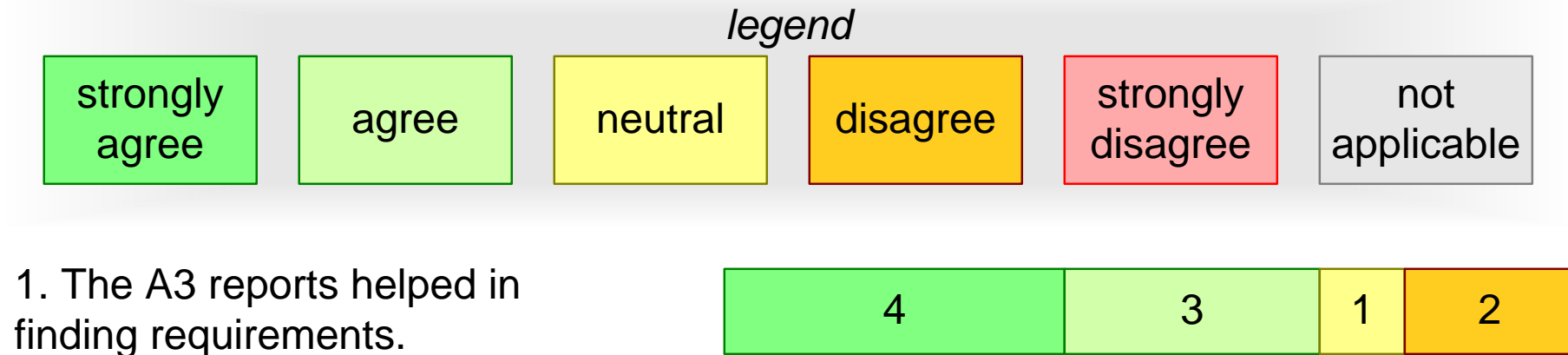
*legend*

| strongly agree | agree | neutral | disagree | strongly disagree | not applicable |
|---|---|---|---|---|---|

| 1. The A3 reports helped in finding requirements. | 4 | 3 | 1 | 2 |
|---|---|---|---|---|

USN  ESI

# Evaluation of Surveys

| strongly agree 5 | agree 4 | neutral 3 | disagree 2 | strongly disagree 1 | not applicable |
|---|---|---|---|---|---|

1. The A3 reports helped in finding requirements.

| 4 | 3 | 1 | 2 |
|---|---|---|---|
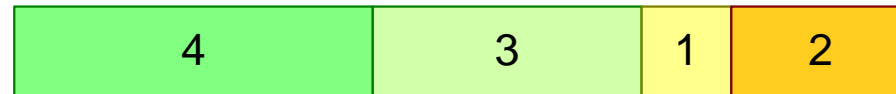
How to assess the outcome? What is "good"?
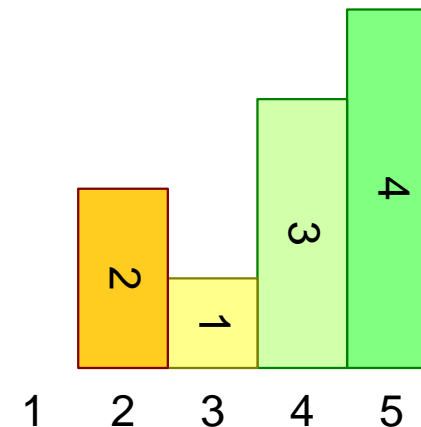
Mean > 3, e.g. better than neutral?          mean = 3.9

Mode or median?          median = 4, mode = 5
  mean, median, and mode are not very differentiating

Net Promotor Score=

(#promotors - #complainers)=

(#strongly agree - (#neutral+#disgaree+#strongly disagree) > 0

NPS = +1

USN  ESI

# References

**Action research:**

http://cadres.pepperdine.edu/ccar/define.html

O'Brien, R. 1998. *An Overview of the Methodological Approach of Action Research*. University of Toronto http://www.web.ca/robrien/papers/arfinal.html#_edn2

Hilary Bradbury Huang, 2010. *What is good action research?: Why the resurgent interest?* Action Research 2010; 8; 93

**Industry-as-Laboratory:**

Colin Potts. *Software-engineering research revisited*. IEEE Software, Vol. 10, No. 5:19–28, September/October 1993.

Gerrit Muller and W. P. Maurice Heemels, *Five Years of Multi-Disciplinary Academic and Industrial Research: Lessons Learned*; CSER 2007 in Hoboken NJ

**Case Study research:**

Robert K. Yin, *Case Study Research Design and Methods*. Sage Publications Inc, 5$^{th}$ edition, May 2013

**Likert Scale:**

Jamieson, Susan. (2004). *Likert scales: how to (ab)use them*. Medical Education. http://xa.yimg.com/kq/groups/18751725/128169439/name/1LikertScales.pdf

**Net Promotor Score:**

Frederich Reichheld *The One Number You Need to Grow,* Harvard Business Review 2003, http://hbr.org/2003/12/the-one-number-you-need-to-grow/ar/1

Keiningham, T, L. Aksoy, L. Cooil, B. Andreassen, T, W. (2008). *Net Promoter, Recommendations, and Business Performance: A Clarification on Morgan and Rego*. Marketing Science.Vol.27, No. 3, May-June 2008, pp. 531-532.  http://www2.owen.vanderbilt.edu/bruce.cooil/Documents/Publications/2008--Marketing%20Science.pdf

**Tools and support** see: https://min.usn.no/student/tjenester-for-studenter/it-tjenester/

USN  ESI