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.
Action Research or Industry-as-Laboratory

source of inspiration

application playground

industry

challenging problems

apply new engineering methods

research

hypothesis

improve

observe results

evaluate
## Systems Engineer vs Researchers

<table>
<thead>
<tr>
<th>systems engineer</th>
<th>researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal work</td>
<td></td>
</tr>
<tr>
<td>elicit needs, specify, design, analyze, integrate, test</td>
<td>observe, experiment, argue, evaluate, write</td>
</tr>
<tr>
<td>attitude</td>
<td></td>
</tr>
<tr>
<td>explain, educate, sell</td>
<td>question everything, proof opposite</td>
</tr>
</tbody>
</table>
Logical Order of Research

- Industrial problem
- Research questions
- Quantified propositions
- Hypothesis
- Criteria
- Options to be researched
- Industrial goal
Simplified Order for Master Project

industrial problem -> industrial goal

SE body of Knowledge

claim

observables

evaluation

research
Clairm: What benefits will your proposed improvements bring?

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

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?

20% or 80% would be better

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 after definition phase in past projects without method
number of changes after definition phase 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"
What to Research; Observe Context

- **people**
  - applying methods and techniques
  - supported by process

- **methods and techniques**
  - produce artifacts

- **artifacts**
  - describe system of interest
  - delivered to stakeholders

- **system of interest**
  - has objectives
  - uses concepts and patterns

- **stakeholders**
  - have concerns

**Diagram:**
- People applying methods and techniques supported by process.
- Methods and techniques produce artifacts.
- Artifacts describe system of interest delivered to stakeholders.
- System of interest has objectives and uses concepts and patterns.
- Stakeholders have concerns.
## Spectra of Research Methods

### Artifacts that researcher can produce

- free format
- no formal definition
+ supports
  - discovery
  - exploration
- difficult for
  - analysis
  - comparison
  - aggregation

### Extracting data from other people

- open interview
- prepared interview
- open question survey
- Likert scale survey
- structured reports

### How the researcher collects data

- log observations
- observation template
- structured data collection

### Artifacts that researcher can produce

- sketch
- block diagram
- spread sheet
- formal model

### Standardized format

- standardized data
- formalized definition
+ supports
  - analysis
  - comparison
  - aggregation
- might
  - restrict inputs
  - affect observation
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

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

from Master Project by Espen Polanscak
### Questionnaire

1. The A3 reports helped in finding requirements.

<table>
<thead>
<tr>
<th>strongly agree</th>
<th>agree</th>
<th>neutral</th>
<th>disagree</th>
<th>strongly disagree</th>
<th>not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Presentation data

1. The A3 reports helped in finding requirements.

**Legend:**
- **strongly agree**
- **agree**
- **neutral**
- **disagree**
- **strongly disagree**
- **not applicable**

```
4 3 1 2
```
Evaluation of Surveys

1. The A3 reports helped in finding requirements.

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=
(#promoters - #complainers)=
(#strongly agree - (#neutral +#disagree +#strongly disagree)) > 0
NPS = +1
References

**Action research:**
http://cadres.pepperdine.edu/ccar/define.html


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

**Industry-as-Laboratory:**


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:**


**Likert Scale:**


**Net Promotor Score:**


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