SOEN 384
Management, Measurement and Quality Control

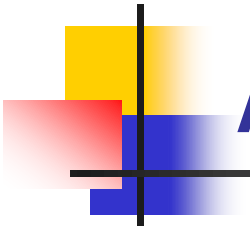
http://users.encs.concordia.ca/~s384_2/

Lecture 6:

Analyzing Software Measurement Data: Examples of simple analysis techniques

References:

Fenton, Chapter 6 – sections 6.3.1, 6.3.2, 6.3.3



Agenda

- Meaningfulness of measurement data analysis
- Simple analysis techniques
  - Exercises
- Next?

Meaningfulness of the analysis of measurement data and Scale Types

- Meaningfulness : book definition

  A statement with measurement values is meaningful *iff* its truth or falsity value is invariant to admissible transformations

  - **Example:**
    - If we say that a *distance between A and B is twice as long as the distance between C and D*, then this statement has to be true or false no matter whether the distance is measured in **centimeters** or **inches**.

Exercise 1: Analyze meaningfully the data and interpret the results

Set 1: *system crash, syntactic, system crash, syntactic, semantic, system crash, system crash*
Set 2*: semantic, system crash, syntactic, semantic, syntactic, semantic*

M1(Set 1): 1,1,2,3,3,3,3 Median1(Set 1): 3
M1(Set2): 1,1,2,2,2,3 Median1(Set 2): 2

Median1 (Set1)**<** Median1 (Set2) **Implies** The average criticality of Set2 is greater than the average of Set1.

Exercise 1 (contd.): Analyze meaningfully the data and interpret the results

	Syntactic	Semantic	system crash.
M1	1	2	3
M2	10	15	16

A statement with measurement values is **meaningful** *iff* its truth or falsity value is invariant to admissible transformations

Median 2 (Set 1): 16
Median 2 (Set 2): 15

Median2 (Set1)< Median2 (Set2) **Implies**
The average criticality of Set2 is greater than the average of Set1.

Median1 (Set1)< Median1 (Set2) **Implies**
The average criticality of Set2 is greater than the average of Set1.

Meaningful Statistics

- Can we always perform **any** mathematical operations on the collected numbers (add them, average them, take logarithms, etc.) **?**

  Why?...

The statistics should be meaningful for the scale type

- The empirical and numerical conditions not covered by the scale type should be considered too.
- Reduced numbers should keep the scale type.

Prove that mean is meaningful for ratio scale data (exercise)

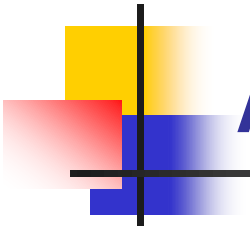
- let {**X1, … ,Xn**} and {**Y1, … ,Yn**} be two sets of entities for which some attribute can be measured on a ratio scale;
- let **M** and **M'** be two measures for the attribute in question.
- Prove that the statement "**The mean of the X_is is greater than the mean of Y_j*s***" is meaningful
  - *Mathematically:*

$$\frac{1}{n}\sum_{i=1}^{n} M(x_i) > \frac{1}{m}\sum_{j=1}^{m} M(y_j) \quad \text{if and only if} \quad \frac{1}{n}\sum_{i=1}^{n} M'(x_i) > \frac{1}{m}\sum_{j=1}^{m} M'(y_j)$$

  - *Note: M = aM' for some a>0*

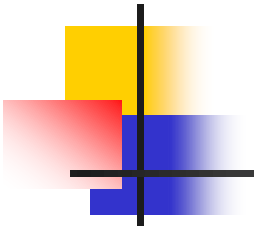
Summary of measurement scales and statistics relevant to each

Scale type	*Defining relations*	*Examples of appropriate statistics*	*Appropriate statistical tests*
Nominal	Equivalence	Mode Frequency	Non-parametric
Ordinal	Equivalence Greater than	Median Percentile Spearman r_S Kendall τ Kendall W	Non-parametric
Interval	Equivalence Greater than Known ratio of any intervals	Mean Standard deviation Pearson product-moment correlation Multiple product-moment correlation	Non-parametric
Ratio	Equivalence Greater than Known ratio of any intervals Known ratio of any two scale values	Geometric mean Coefficient of variation	Non-parametric and parametric



Agenda

- Meaningfulness of measurement data analysis
- Simple analysis techniques
  - Exercises
- Next?



Box Plot

- **Data Analysis Question:** what is the range of acceptable values for the measure?
- **Technique:** robust (summary) statistics can be presented in a visual form called a "box plot"
- ***Box plot*** – a summary of the range of a set of data about **one** variable (where most of the data are clustered, outlier data)

Box-Plot Statistics: appropriate from the ordinal scale type

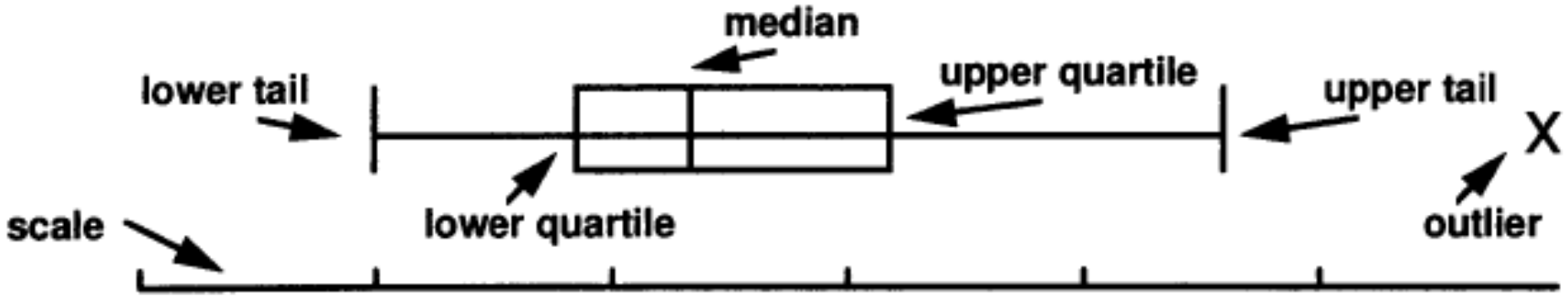


Figure 6.6: Drawing a box plot

Box Plot Example

- **Collected data:** set of attribute values (say, LOC) obtained from a set of related items (classes):

  2,4,8,5,4,11,5,11,8,10,15,11,16

  Step 1: Order (increasing):

  2,4,4,5,5,8,8,10,11,11,11,15,16

  Step 2: Find the Median

  the value that divides the data set in half (i.e., the 7th value –>**8**)

  Step 3: Lower and Upper Quartiles (Fourths): values that together with the median split the data set into quarters (**5** and **11**, respectively)

2,2,4,5,5,8,8,10,11,11,11,15,16

- Lower and Upper Quartiles (Fourths)?

  RE: "Statistics for Engineering and the Sciences", W. Mendenhall et al.

- **LQ(lower forth)** : calculate the quantity

  LQ=1/4 *(n+1) and round to the nearest integer; the measure with this rank represents the lower quartile.

  round(¼ * 14) ->4 pos. => LQ= **5**

- **UQ(upper forth) :** calculate the quantity
  - UQ=3/4 * (n+1) and round to the nearest integer; the measure with this rank represents the upper quartile.

    round(3/4 * 14) ->11 pos. => UQ = **11**

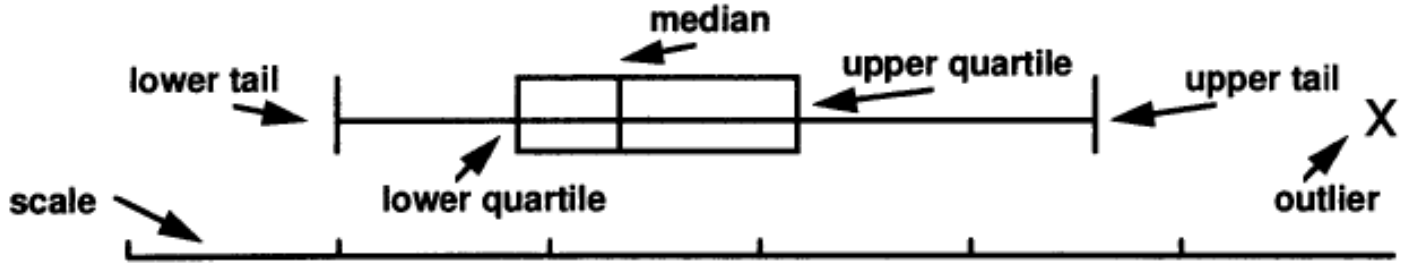


Figure 6.6: Drawing a box plot

- **Step 4:** calculate the **Box Length:**
  - the 'distance' between the lower to upper fourth
  - (11-5=**6**)
- **Step 5: calculate Upper and Lower Tails:**
  - multiplying the box length by 1.5 (6x1.5=9)
  - adding and subtracting 9 from the upper and lower fourths
  - {11+9=**20** and 5-9 -> **0** respectively}.
  - **Here, lower tail is truncated at zero because a negative number of paths is not meaningful.**

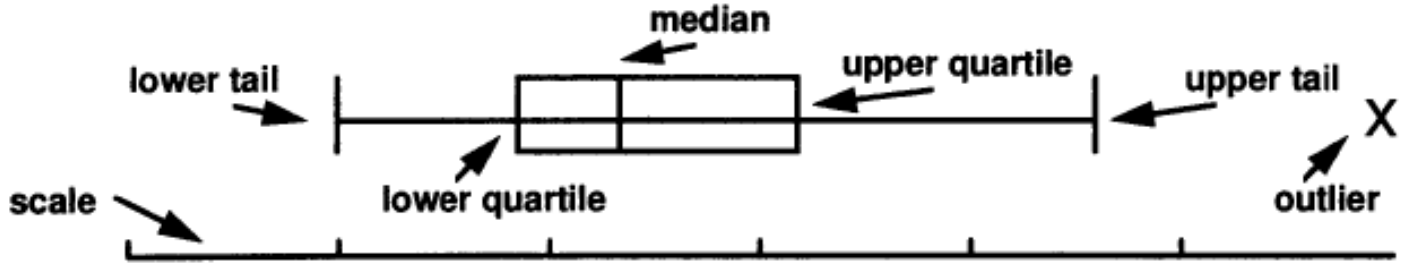


Figure 6.6: Drawing a box plot

- ***Data: 2,4,8,5,4,11,5,11,8,10,15,11,16***
- **Acceptable Range: [Lower forth, Upper forth]**
  - **Example: values in the range [5..11] (5,5,8,8,10,11,11,11)**
- **quick review** of the components with values in

[lower tail .. lower forth[U]upper forth .. upper tail]

Example: values in [0..5[U]11..20] (2,4,4,15,16)

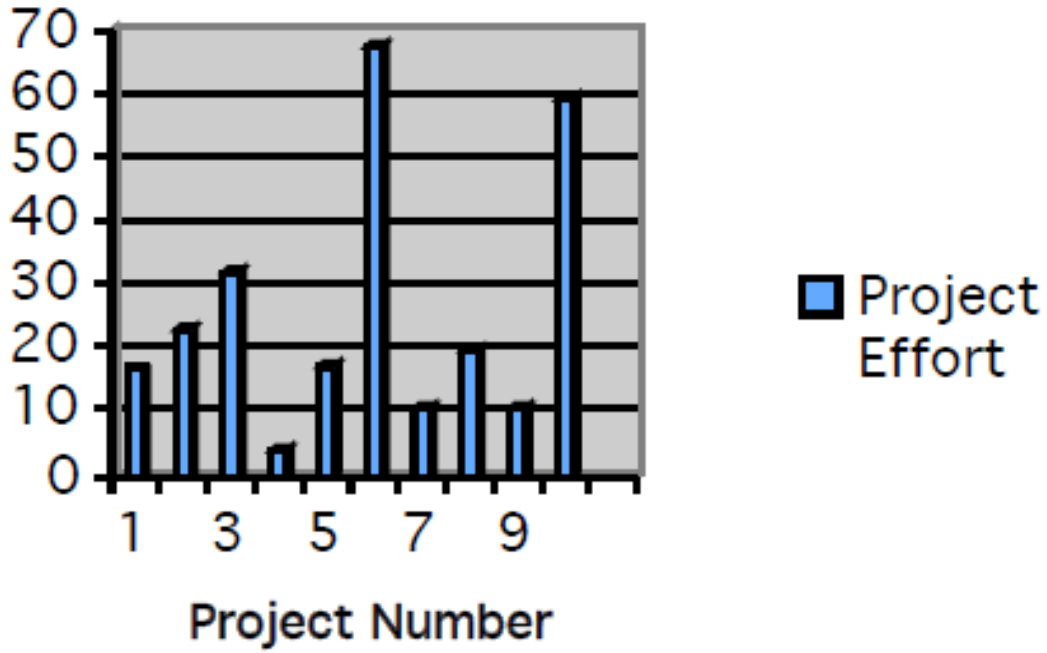
- **More stringent review** of components that are statistical outliers with values greater than the upper tail or less than the lower tail
  - **Example: >20 (none)**

• Box plots **point us to** abnormal or unusual behavior.
• On the other hand, they can also help us to see **what is** usual or normal.

- Range of **acceptable** values: which entities are acceptable?
- Range of **quick review** values: which entities should be reviewed?
- Identify **statistical outliers**: which entities are unacceptable?

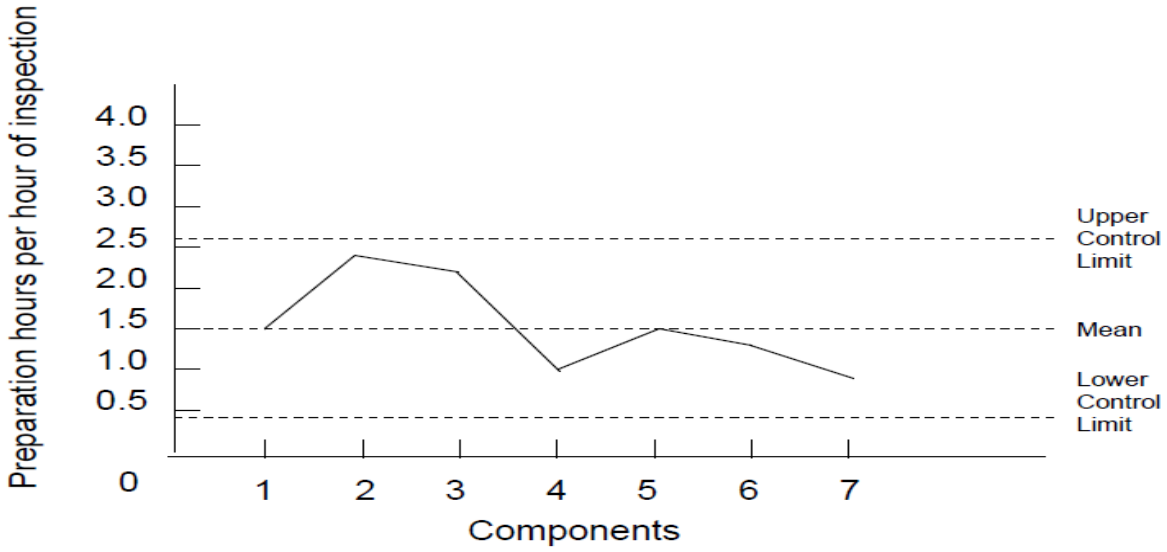
Bar Chart

- displays all the data ordered to see what the patterns or trends may be.

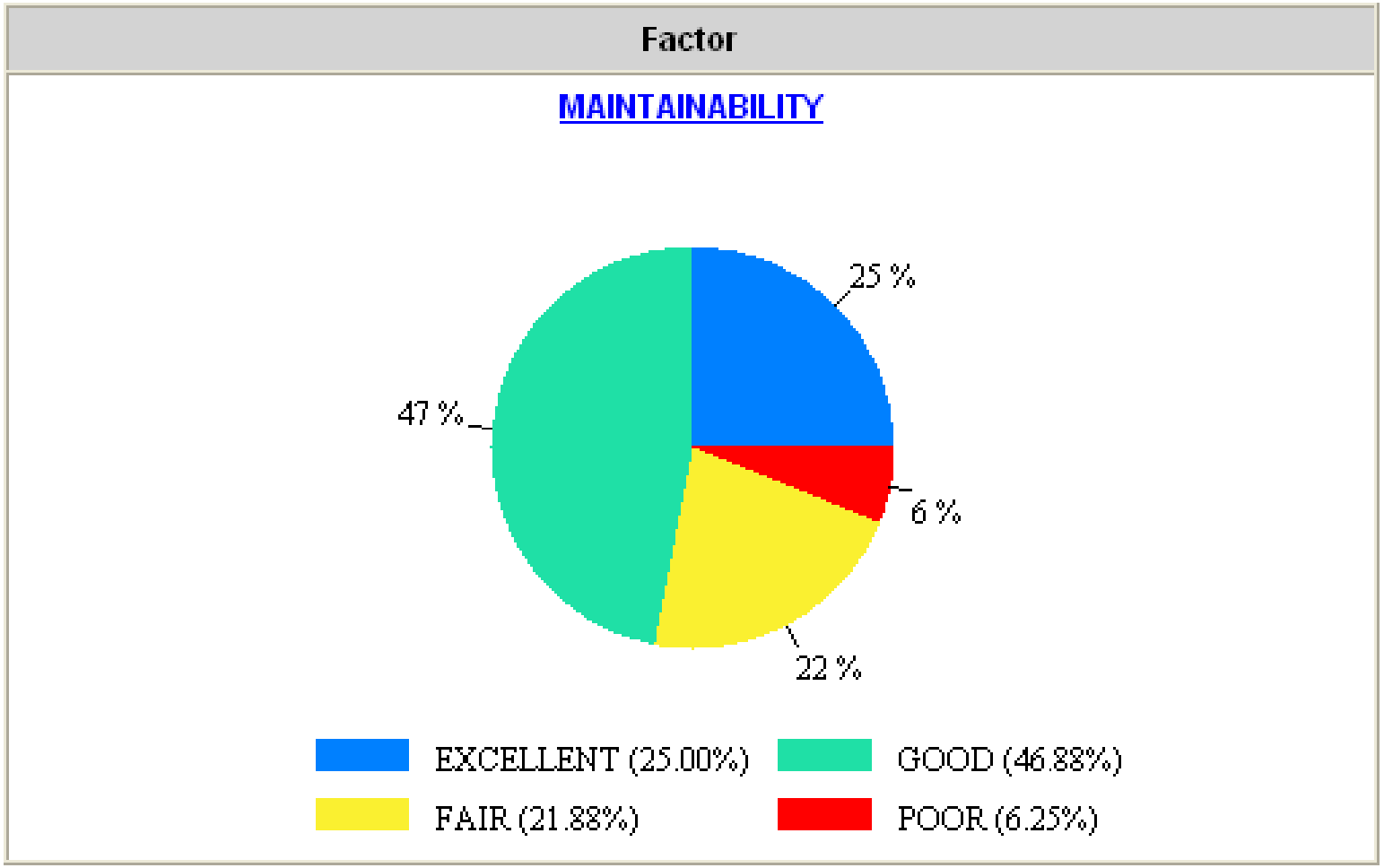


Control Charts:

- *control chart* graph shows the upper control limit, the mean, and the lower control limit
- The control limits act as guidelines for understanding when the data are within random statistical variation and when they represent unusual behavior



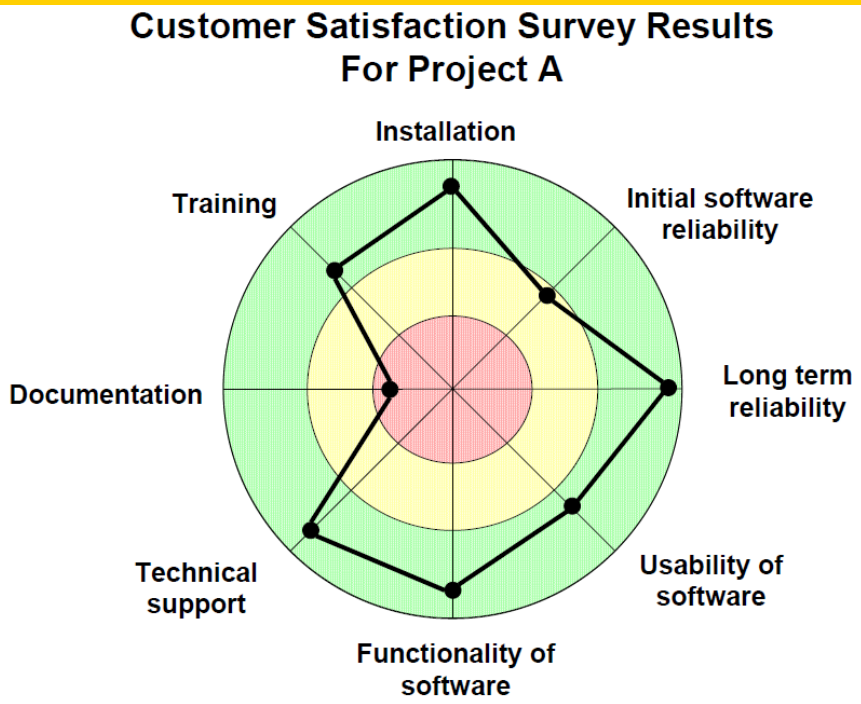
Pie Graph

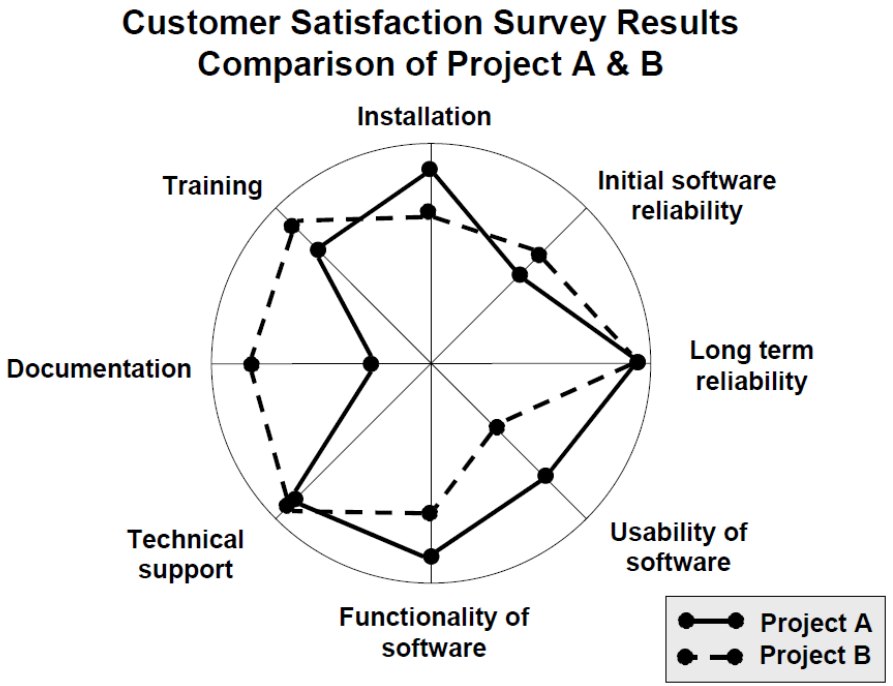

Factor
MAINTAINABILITY
25 %
47 %
6 %
22 %
EXCELLENT (25.00%)
GOOD (46.88%)
FAIR (21.88%)
POOR (6.25%)

Kiviat Charts

Example source:
http://www.westfallteam.com/sites/default/files/papers/Kiviat%20Charts.pdf

- Each "spoke" represents a measure with the measure's value plotted on that spoke.
- The outer circle symbolizes upper bounds and the inner circle symbolizes lower bounds.

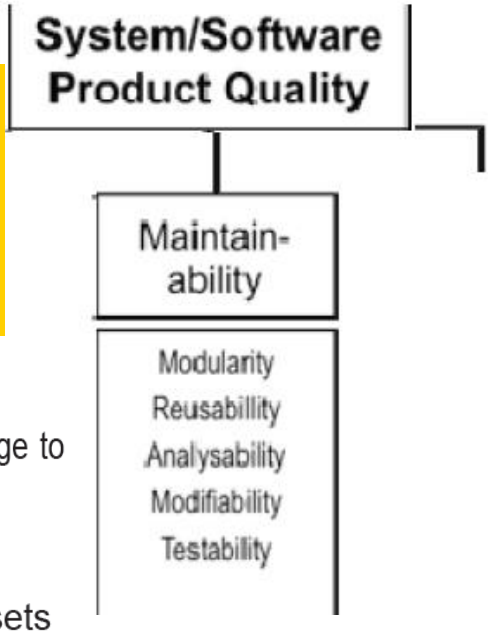




ISO 25010: Maintainability

ISO/IEC 25010:2011(E)

Definition: degree of effectiveness and efficiency with which a product or system can be modified by the intended maintainers



4.2.7.1
modularity
degree to which a system or computer program is composed of discrete components such that a change to one component has minimal impact on other components

4.2.7.2
reusability
degree to which an asset can be used in more than one system, or in building other assets

4.2.7.3
analysability
degree of effectiveness and efficiency with which it is possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures, or to identify parts to be modified

4.2.7.4
modifiability
degree to which a product or system can be effectively and efficiently modified without introducing defects or degrading existing product quality

Modifiability is a combination of changeability and stability.

4.2.7.5
testability
degree of effectiveness and efficiency with which test criteria can be established for a system, product or component and tests can be performed to determine whether those criteria have been met

LOGISCOPE: Maintainability

MAINTAINABILITY = ANALYZABILITY + CHANGEABILITY + STABILITY + TESTABILITY

4.2.7.3
analysability
degree of effectiveness and efficiency with which it is possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures, or to identify parts to be modified

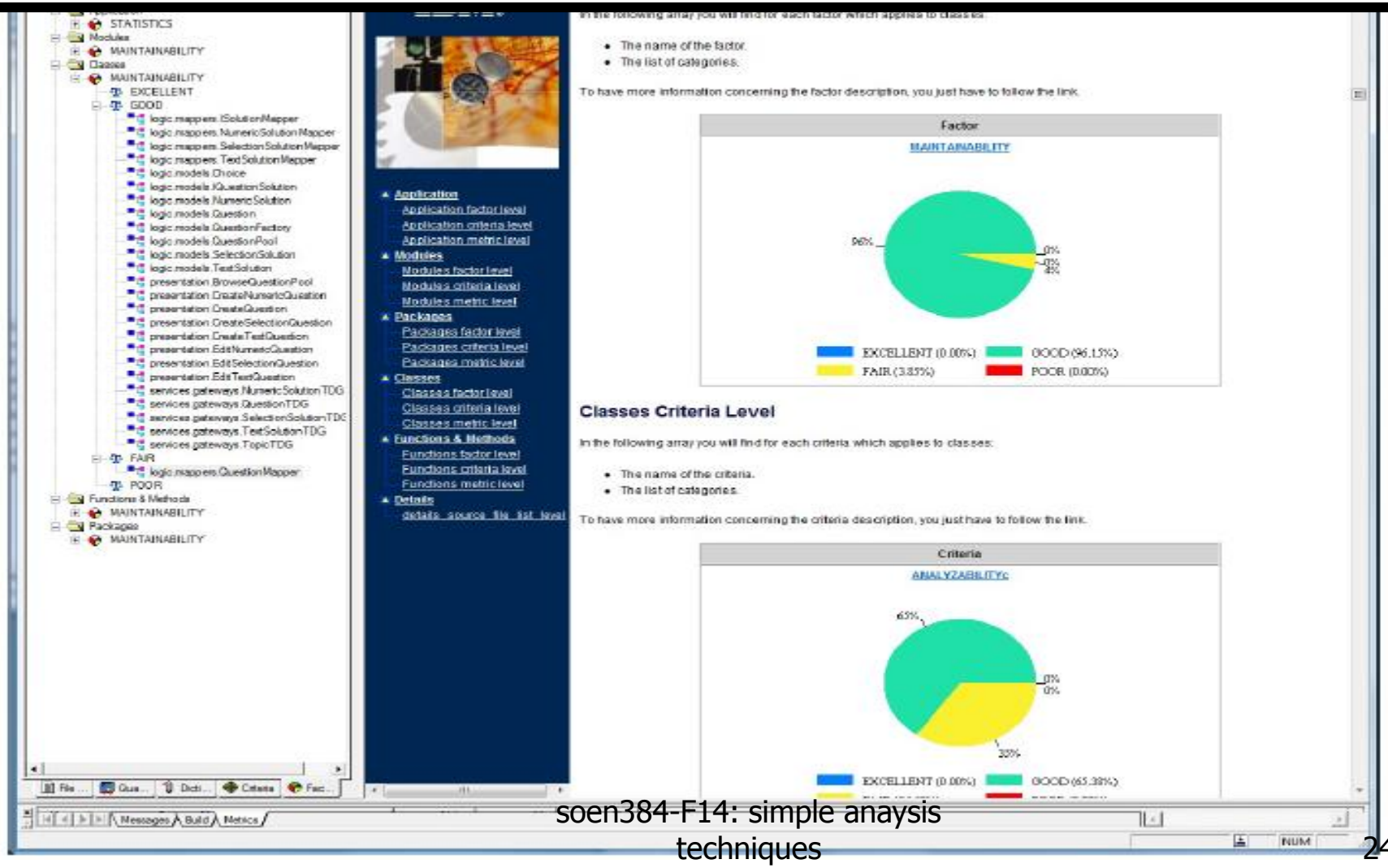
4.2.7.4
modifiability
degree to which a product or system can be effectively and efficiently modified without introducing defects or degrading existing product quality

Modifiability is a combination of changeability and stability.

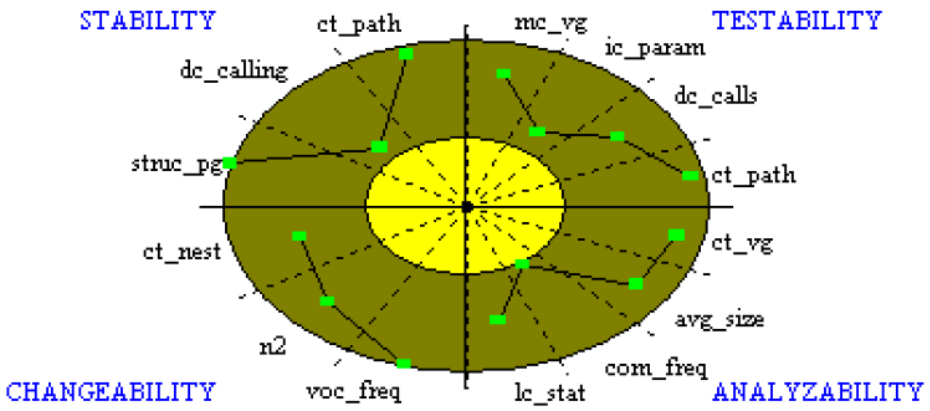
4.2.7.5
testability
degree of effectiveness and efficiency with which test criteria can be established for a system, product or component and tests can be performed to determine whether those criteria have been met

Logiscope tool

$$MAINTAINABILITY = ANALYZABILITY + CHANGEABILITY + STABILITY + TESTABILITY$$

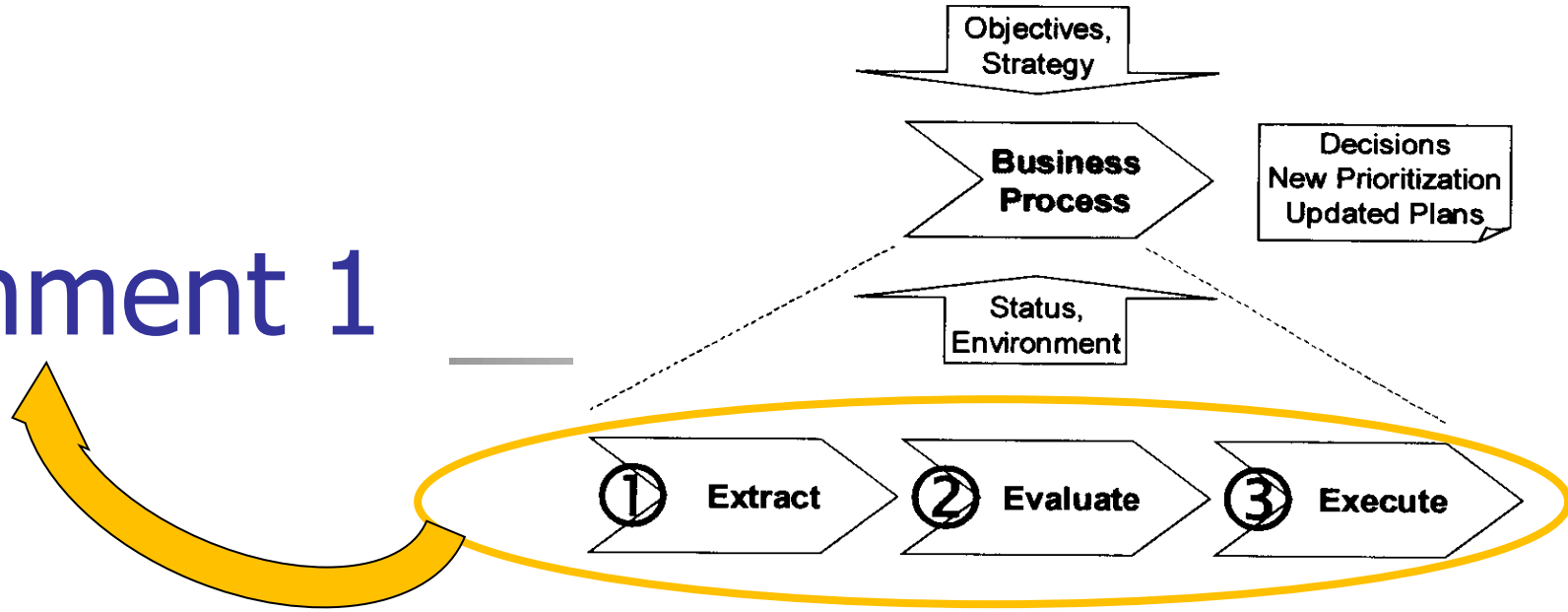


Logiscope Criteria Kiviat Graph

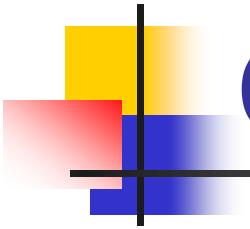


CRITERION	CLASS
TESTABILITY	EXCELLENT
STABILITY	EXCELLENT
CHANGEABILITY	EXCELLENT
ANALYZABILITY	EXCELLENT

Assignment 1

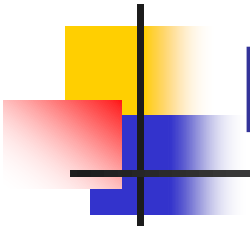


- **Part 1:** Collect and analyze quality data with McCabe
  - Quality trend
- **Part 2:** Collect and analyze quality data with Logiscope
- **Source**: soen390 projects



Questions?

- ...



Next?

- Simple measurement program