第三届（2018）

中国软件成本度量大会

暨 IWSM-MENSURA INTERNATIONAL CONFERENCE

Software Cost Measurement: Recent Developments & Trends and a Strategy for the Future

演讲人：Alain Abran

Software Cost Measurement: Recent Developments & Trends and a Strategy for the Future

Alain Abran

Chinese national Cost Measurement Conference
Beijing (China) September 18, 2018

Presenter background - Alain Abran

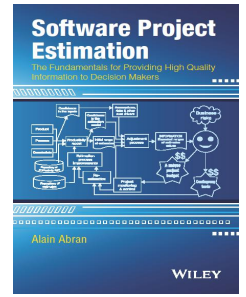
20 years

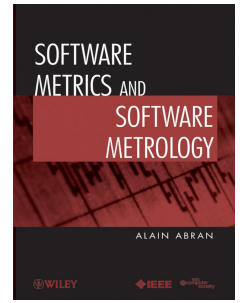
- **Development**
- **Maintenance**
- **Process Improvement**

+ 20 years

45 PhD

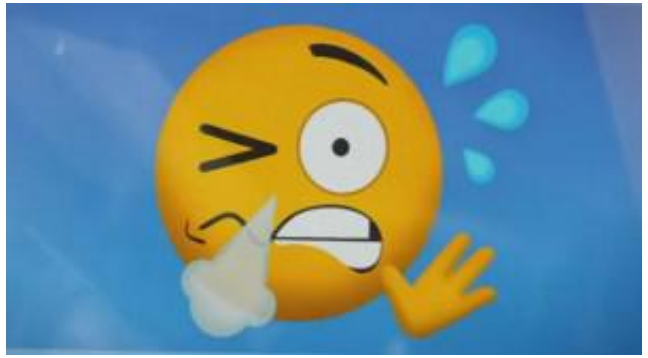
ISO: 19761, 9126, 25000, 15939, 14143, 19759





Standish Group Chaos Report

- 25,000 software projects (2011-2015)
  - 27-31% Successful (on-budget, on-time, value-satisfactory)
  - 17-22% Failed (cancelled or rejected on delivery)
  - 49-56% Challenged (satisfactory but well over budget and schedule)
- Average annual budget overrun: 68-72%
- Average annual schedule overrun: 66-81%



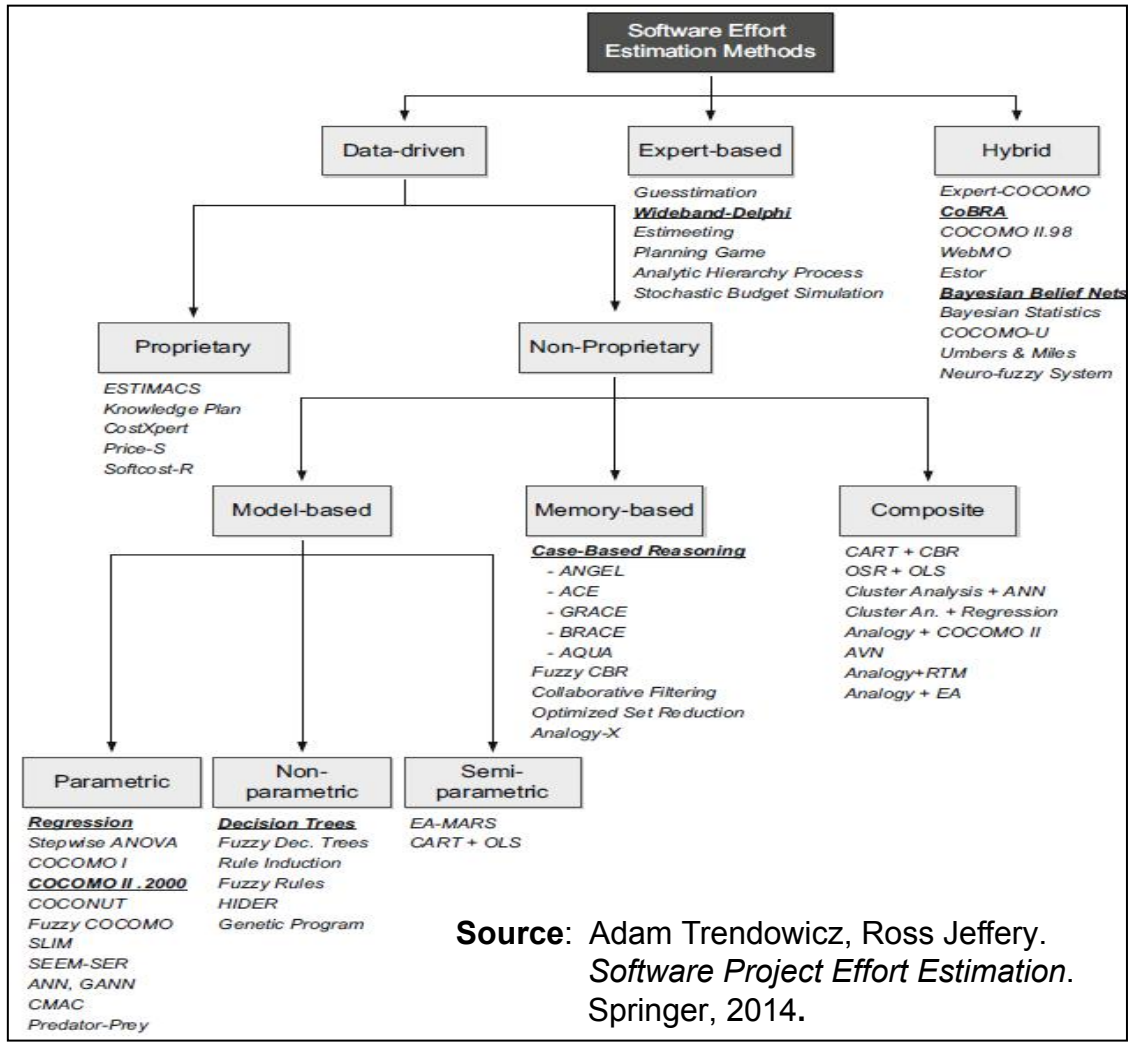
Source: J. Johnson. *My Life Is Failure,* Standish Group Intl., 2016.

List of topics

1. Estimation Models
2. Size Measurement techniques
3. Size as the dominant factor for Estimation models.

List of topics

1. **Estimation Models**
   - **Overview & Summary Assessment of Research & Industry Models**
2. Size Measurement techniques
3. Size as the dominant factor for Estimation models.



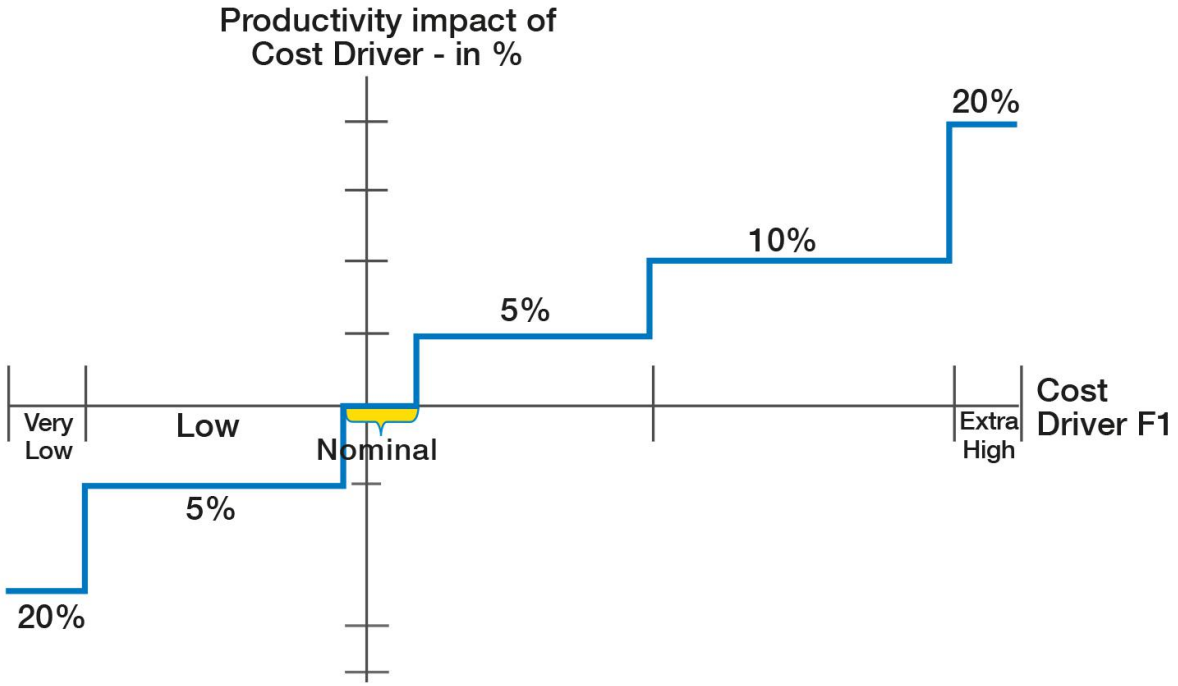
Source: Adam Trendowicz, Ross Jeffery. *Software Project Effort Estimation*. Springer, 2014.

Effort Estimation Models in Research:

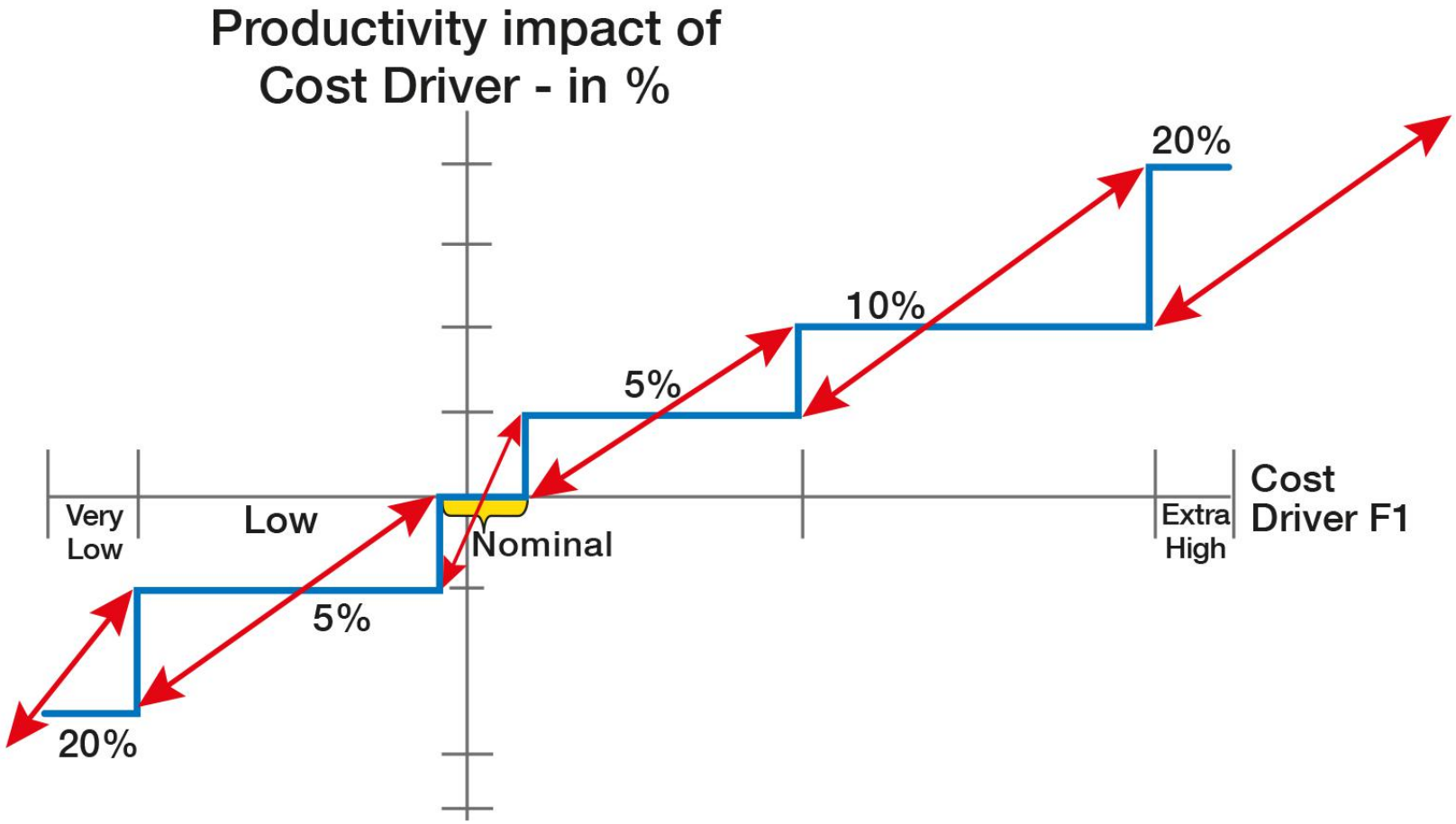
- very large variety of mathematical techniques
- too many parameters for the size of samples
- no hypothesis testing - almost random searches
- + 40 years old data sets used for testing the models,
- Black boxes: no rationale for decision making & control

Effort estimation models in industry = 'COCOMO-like' Step Functions

Impact guessed by 'experts'



Step-function = Approximation



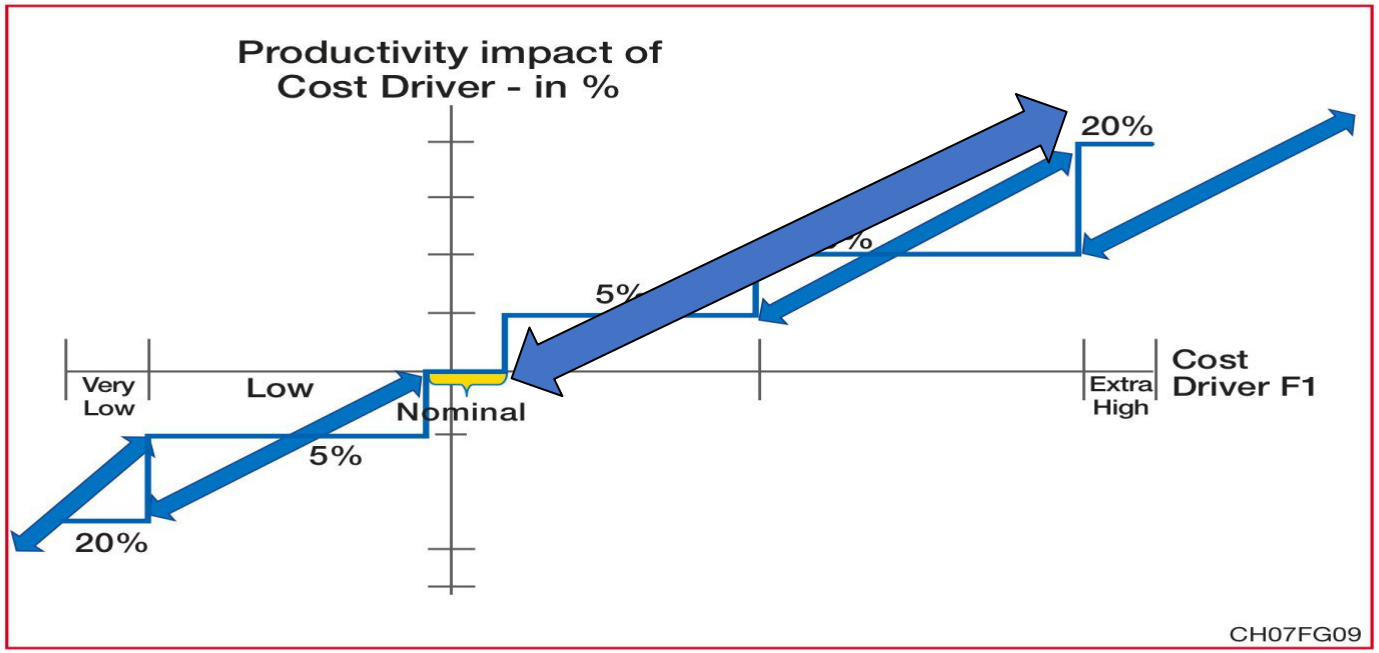
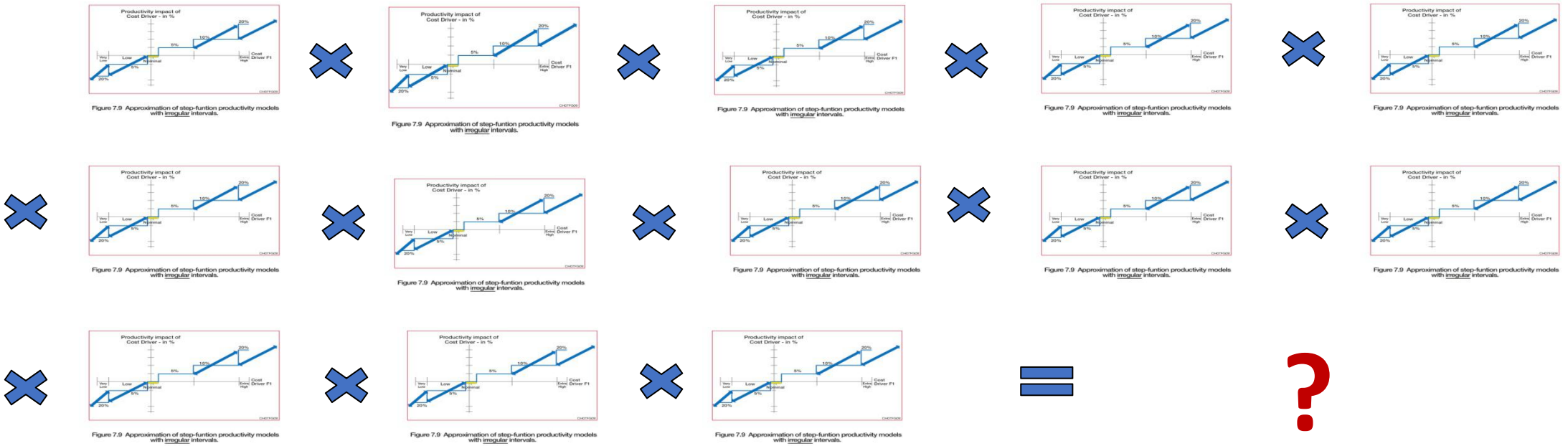


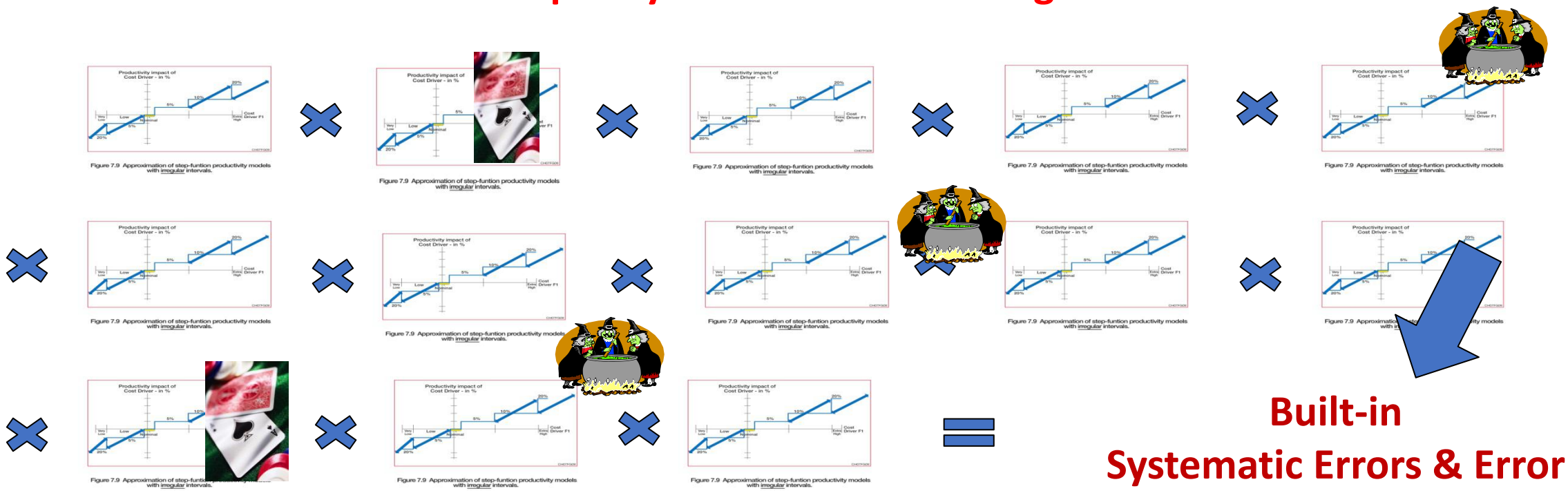
Figure 7.9 Approximation of step-funtion productivity models with irregular intervals.

Each COCOMO cost driver = an estimation sub-model with unkown quality & large errors

COCOMO-like estimation models:
Effort is a function of Size & step-functions



COCOMO-like estimation models:
Effort is a function of Size Step-functions)
of unknown quality combined into a single number!



Built-in Systematic Errors & Error Propagation

Estimation models with too many factors (in industry & research)

The ***'feel-good'***,

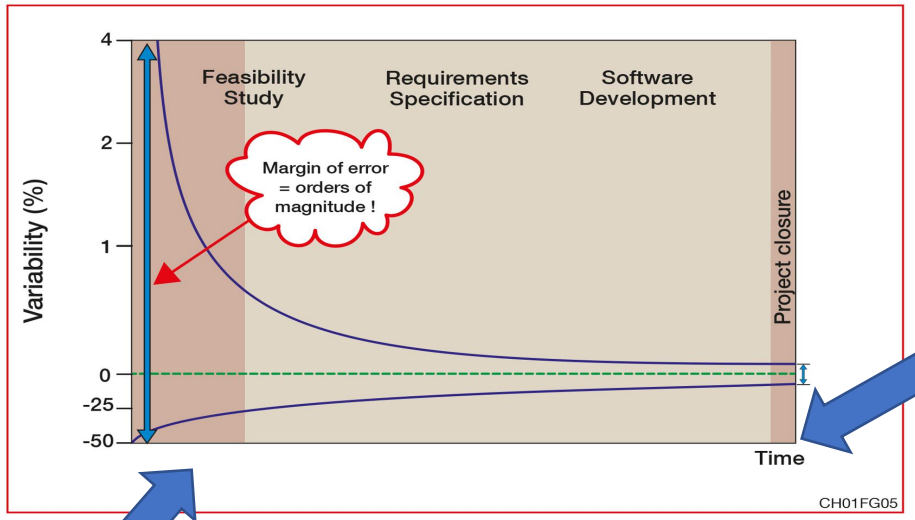
Quick & Easy…

Estimation Models with too many factors….

The ***'feel-good"*** → dead end!

Quick & Easy…

Summary Assessment of many of the ‘widely used’ estimation practices in Research & Industry



Research in Academia !!!

Industry: too many variables bundled together to make you ‘feel good’!

List of topics

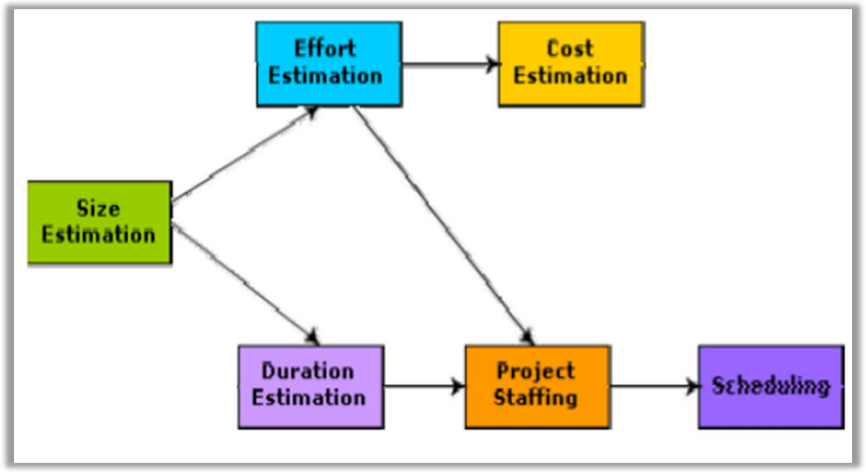
1. Estimation Models:
   - Overview & Summary Assessment of Research & Industry Models

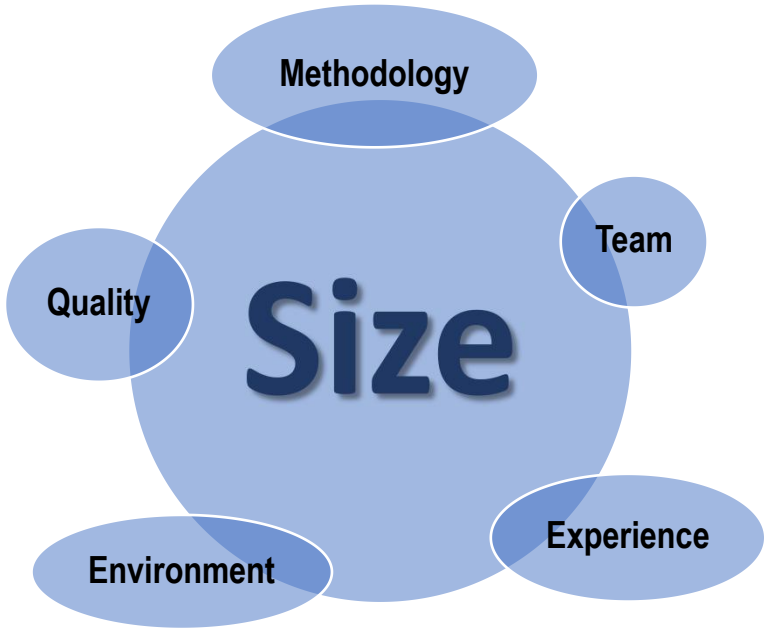
2. **Size Measurement techniques:**
   - **Overview & Summary Assessment**

3. Estimation models for decision making, monitoring & control.

Software Size:

- A necessary condition for estimation
- A dominant variable





Bad & Good Examples:

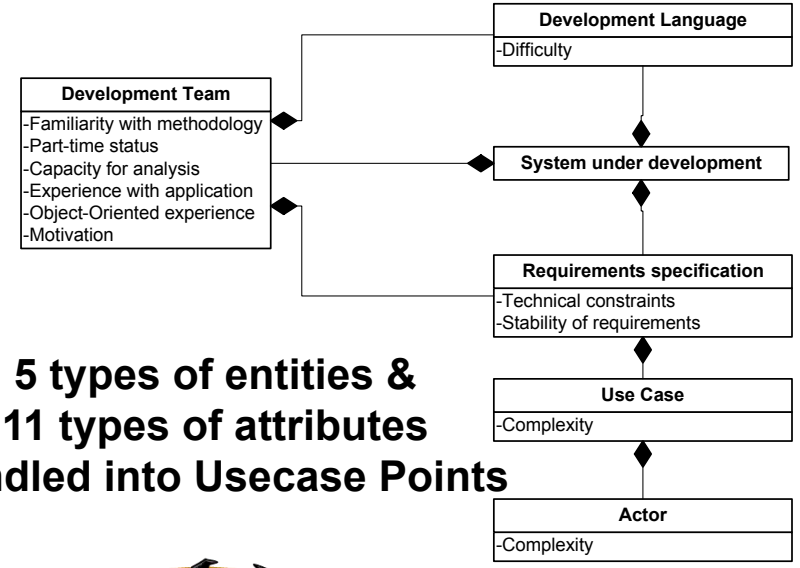
1. Usecase Points & SNAP Points

2. Story Points

3. Function Points

Usecase Points

Table 1: Entities, Attributes, and Measurement Rules		
Entity	**Attribute**	**Measurement rule**
Actor	Complexity (of actor)	The type of complexity (simple, average, or complex) of the interaction between the actor and the system
Use case	Complexity (of use case)	The type of complexity (simple, average, or complex) measured in the number of transactions
Specification of requirements	Relevance of the technical quality requirements	The level of relevance (from 0 to 5) of each of the 13 known non-functional qualities
	Stability of the requirements	The level of stability (from 0 to 5) of the functional and non-functional requirements
Development team	Familiarity with the methodology	The level (from 0 to 5) of skills and knowledge of the development methodology in use for the project.
	Part-time status	The level (from 0 to 5) of part-time staff on the team
	Analysis capability	The level (from 0 to 5) of analysis capabilities of the development team with respect to project needs
	Application experience	The level (from 0 to 5) of team experience with the application domain of the system
	Object-oriented experience	The level (from 0 to 5) of team experience with object-oriented design
	Motivation	The level (from 0 to 5) of team motivation
Programming language	Difficulty	The level (from 0 to 5) of programming difficulty



5 types of entities &
11 types of attributes
Bundled into Usecase Points

It fails primary school maths!

Sizing Non-Functional Requirements:
SNAP Points

Scale type		Admissible Transformation	Operations	Examples
Nominal	(R,=)	f unique	Name, distinguish	Colors, shapes
Ordinal	(R,>=)	f strictly increasing monotonic function	Rank, Order	Preference, hardness
Interval	(R,>=,+)	f(x)= ax + b, a>0	Add	Calendar time, temperature (degrees Celsius)
Ratio	(R,>=,+)	f(x)= ax, a>0	Add, multiply, divide	Mass, distance, absolute temperature (degrees Kelvin)
Absolute	(R,>=,+)	f(x)= x	Add, multiply, divide	Entity count

It fails
primary school maths!

Category	Sub-concepts for the classification	SNAP weights basis
Data Entry Validation	Nesting level complexity	2,3,4 * number of DETs
Logical operations	Control flow complexity	4,6,10 * number of DETs
Mathematical operations	Control flow complexity	4,6,10 * number of DETs
Data formatting	Transformation complexity	2,3,5 * DETs
Internal data movements	Internal boundaries crossed DET transferred	5* (# of internal boundaries crossed)+2*(#DETs)
Functionality by data config.	Complexity	3,4,6 * Number of records
UI Changes	UI types complexity	2,-,4 * DETs
Help methods	Help types	1,2,3 * number of Help items
Multiple input methods	Media types	3,4,6 * number of controls
Multiple output methods	Media types	3,4,6 * number of controls
Multiple platforms	No. of platforms to operate	8 * Number of platforms
Database technologies	Level & type of normalization of the physical schema	1,3,4,5,7 * levels of normalization
System configuration		SP=(middleware config.)+2*(# backend config.) +3*(# interface config.)
Batch processing	Number of batches or transactions	2*(number of batches or transactions)
System critical (real-time)	- Type of transactions - No. critical trans.	5,10,15 * number of critical transactions
Component based software	Type of components (In-house reuse or 3rd party component	4,8 * number of unique components
Design complexity	Interface complexity	8,16,24 *# of COTS applications + 12,24,36 *#nonCOTS applications

Planning Poker & Story Points in Agile: Do they meet measurement criteria?

- Repeatability:
  - different individuals, in different contexts, at different times, & following the same measurement procedures will **NOT** obtain the same measurement results.
- Measurement results:
  - obtained with minimal judgment.
  - results auditable.

FAIL

FAIL

FAIL

Story Points

- **Unaccountability…..!**

Function Points

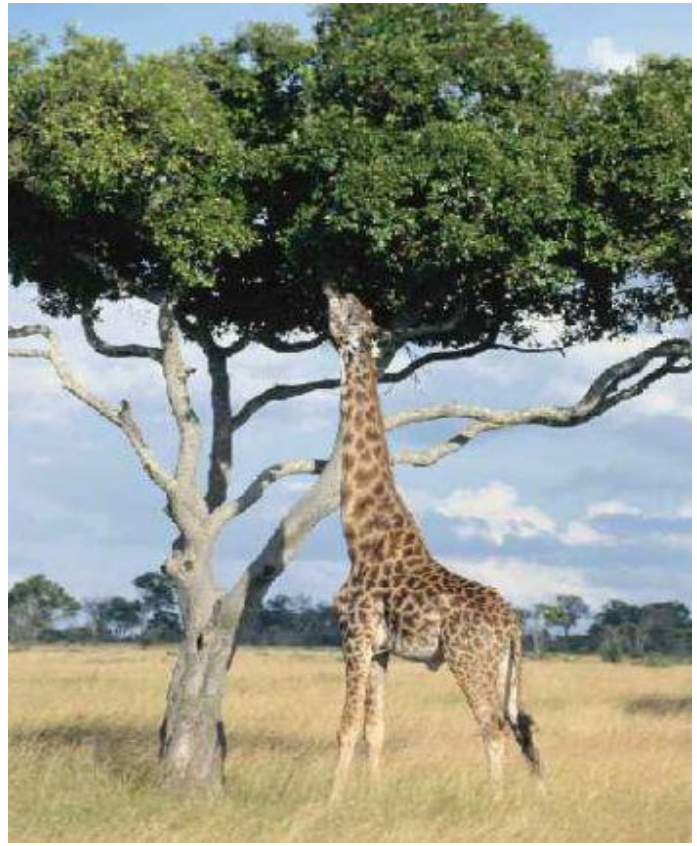
5 distinct ISO standards

- ISO 20926 : IFPUG
- ISO 24570 : NESMA
- ISO 20968 : MRKII
- ISO 29881 : FISMA

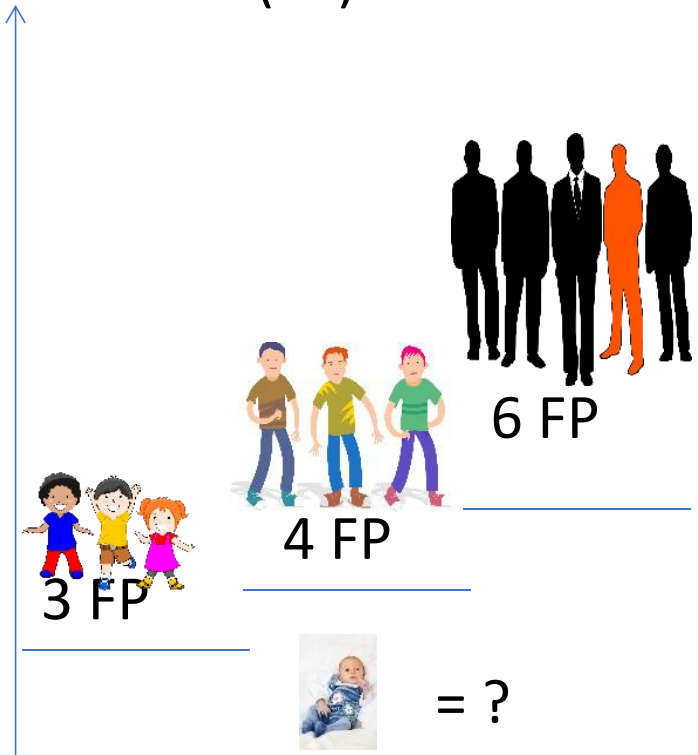
1st Generation

- ISO 19761 : COSMIC → 2nd Generation

1st Generation of Function Points



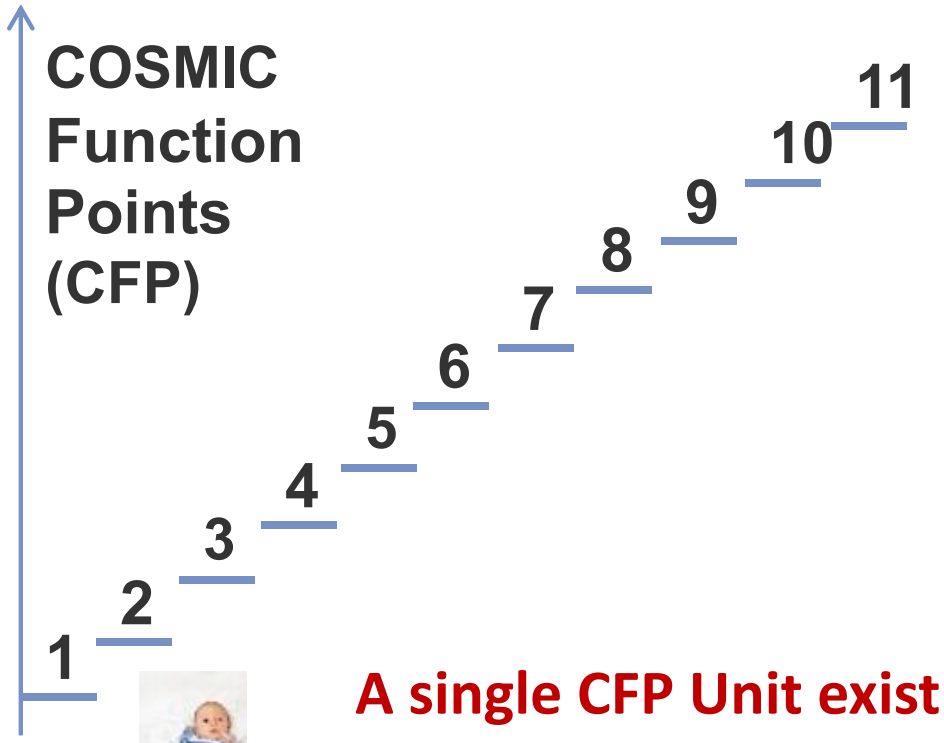
Function Points (FP)



Key limitations:

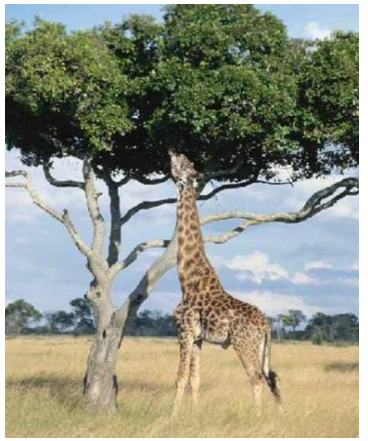
- **Only 3 values**
- **Limited ranges (min,max)**
- **No single measurement unit of 1 FP!**

2nd Generation: COSMIC – ISO 19761



No arbitrary Max

A single CFP Unit exist & is well defined

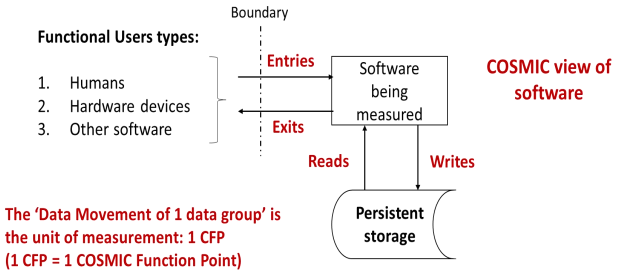


Largest observed functional processes:

In avionics >100 CFP

In banking > 70 CFP

COSMIC - at any level of software requirements



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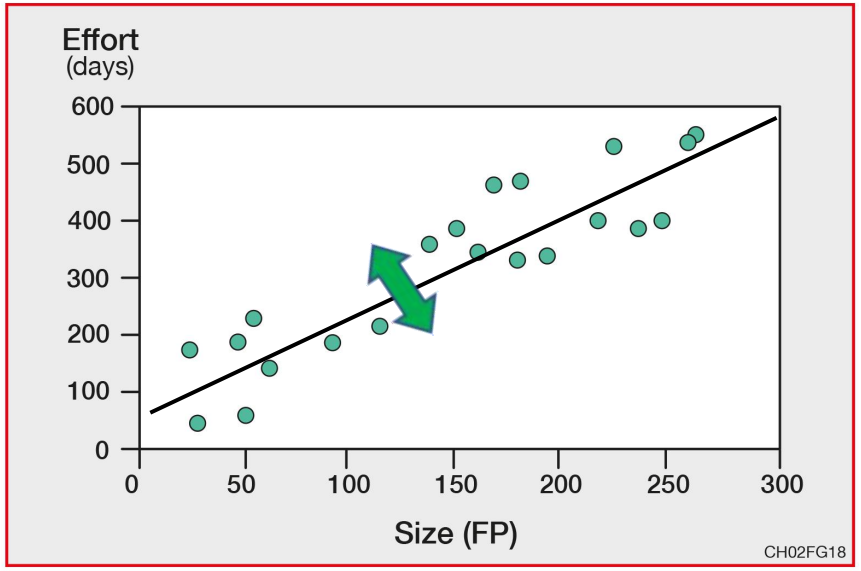
3. **Size as the dominant factor for Effort estimation:**
   - Estimation models for decision making, monitoring & control

Size as a dominant variable in a dataset

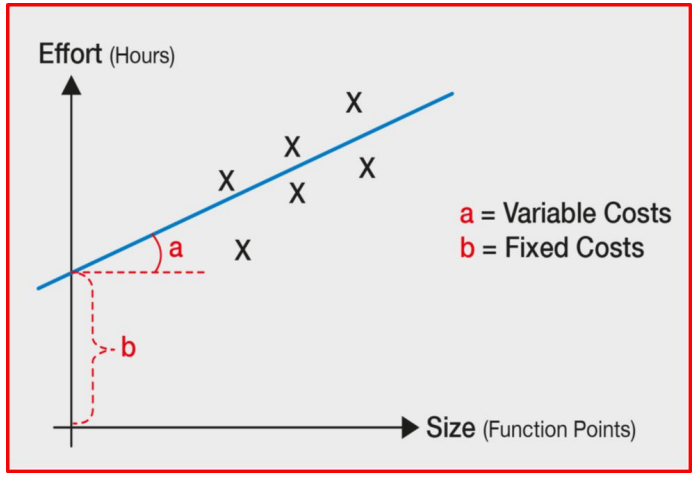


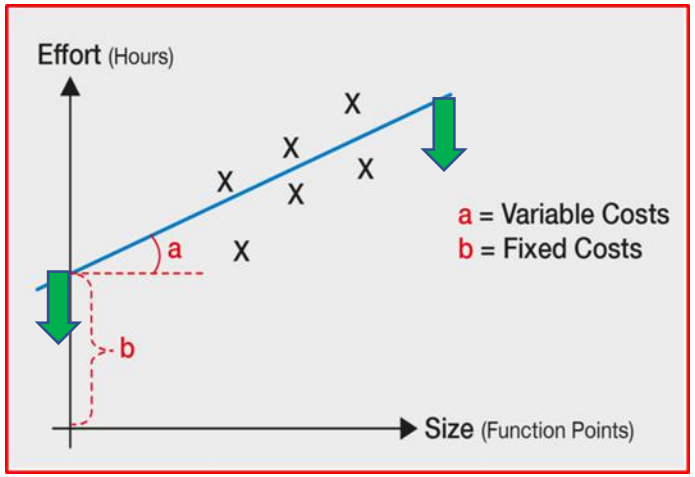
Homogeneous dataset of 21 projects (Abran 1994)

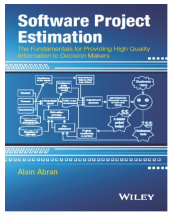
In a development process under control:

- Size explains **80 to 90%** of the Effort variation
- **all other factors combined impact 5% to 20%!**

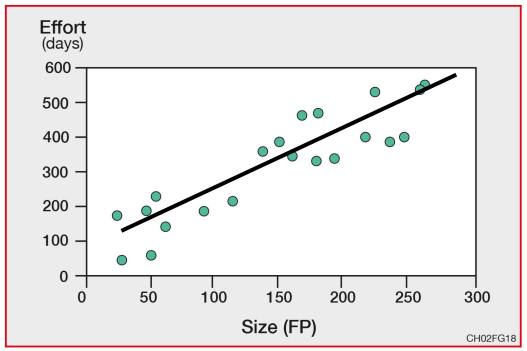
Models based on Economics concepts







Size as a dominant variable in a dataset



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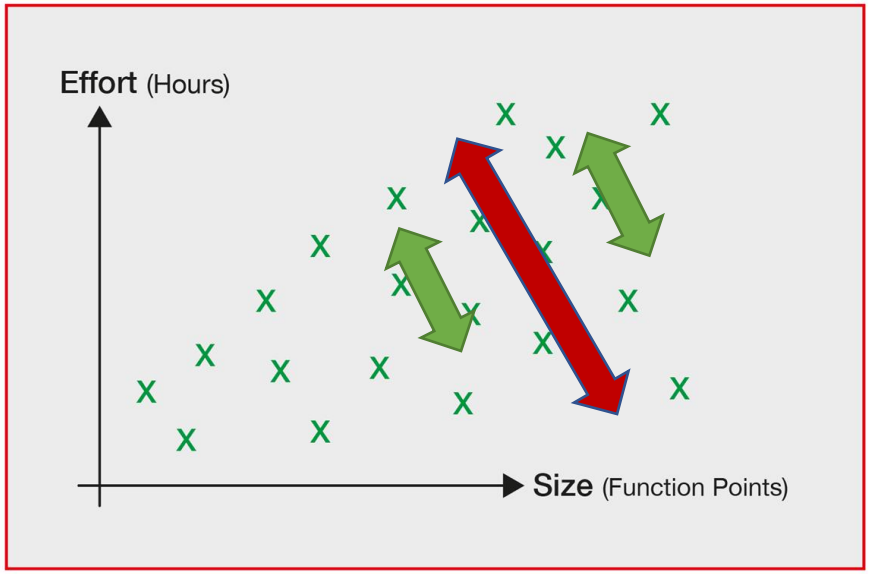
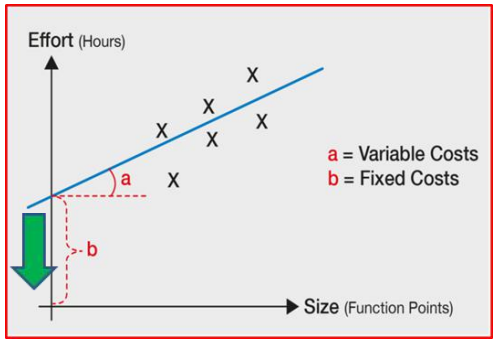


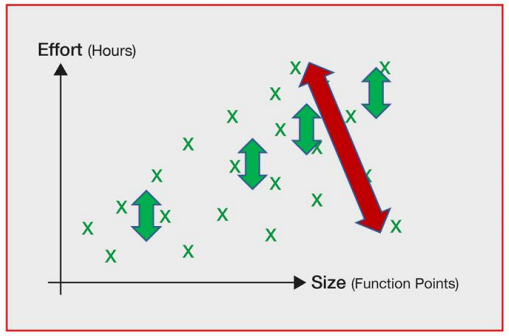
Development Process out of control!

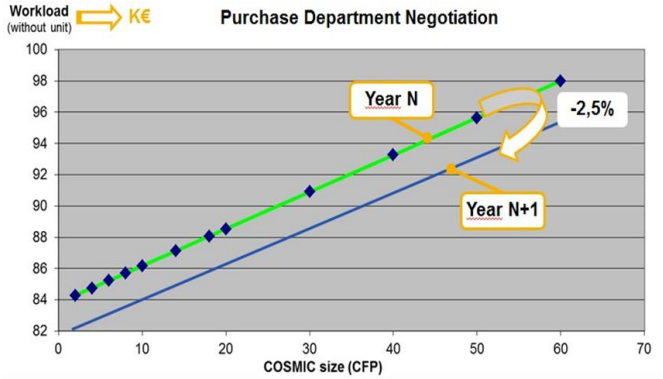
- Management investments required to get the development process back to within control limits

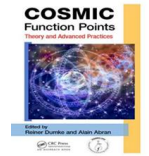
Size as the dominant factor for Effort estimation in development processes under control:

- Estimation models for decision making, monitoring & control.



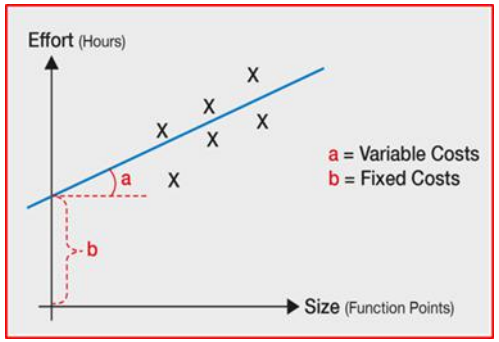






Conlusion

Simpler size-based Estimation Models :



- They provide better management information than complex black-boxes estimation models (**‘feel good’** models or placebos models)


THANK YOU

AUTOMATION ACCURACY WITH COSMIC:

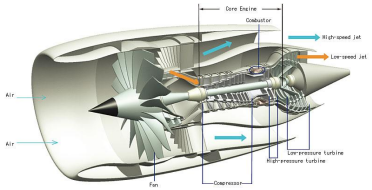
Automation in Industry

Total Number of Models	Total Size obtained manually (CFP)	Total Size obtained using the prototype tool (CFP)	Difference (%)	Accuracy
76 fault-free models	1,729	1,739	Less than 1%	>99%
All 77 models	1,758	1,791	1.8%	>98%

Ref. : Hassan Soubra, Alain Abran, A. R. Cherif,
'Verifying the Accuracy of Automation Tools for the Measurement of Software with COSMIC – ISO 19761 including an AUTOSAR-based Example and a Case Study,'
Joint 24rd International Workshop on Software Measurement & 9th MENSURA Conference, Rotterdam (The Netherlands), Oct. 6-8, 2014, IEEE CS Press, pp. 23-31.

Conclusion

Software ?



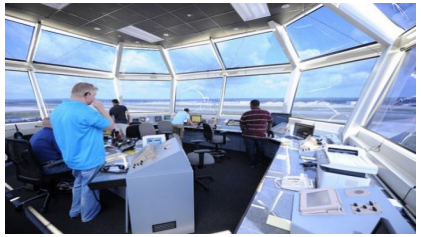


TABLE 1.4 SI Base Units

Physical Quantity	Name of Unit	Abbreviation
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s[a]
Temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A
Luminous intensity	Candela	cd

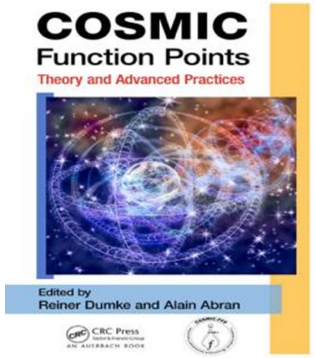
[a]The abbreviation sec is frequently used.

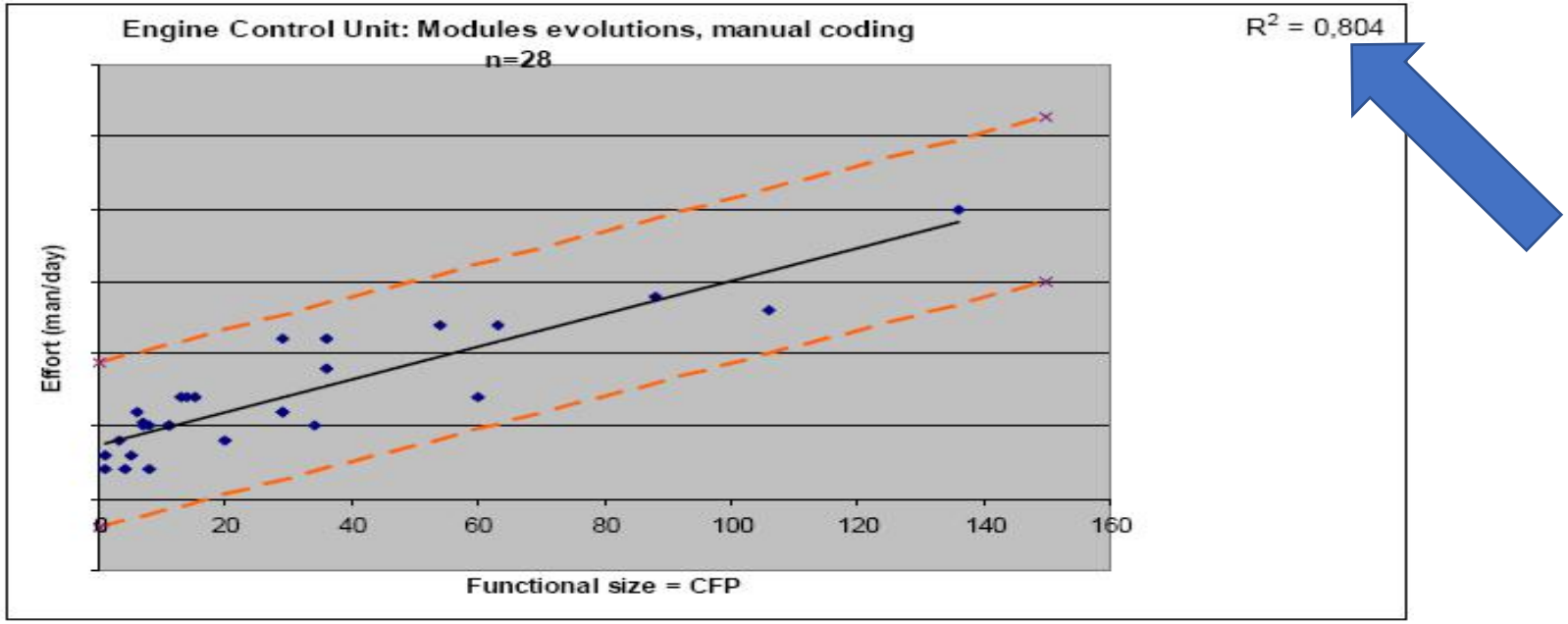
COSMIC

COSMIC method in Automotive embedded software

By: Sophie Stern

Renault





Agile approach (simplified view)

Short deadline - Iteration

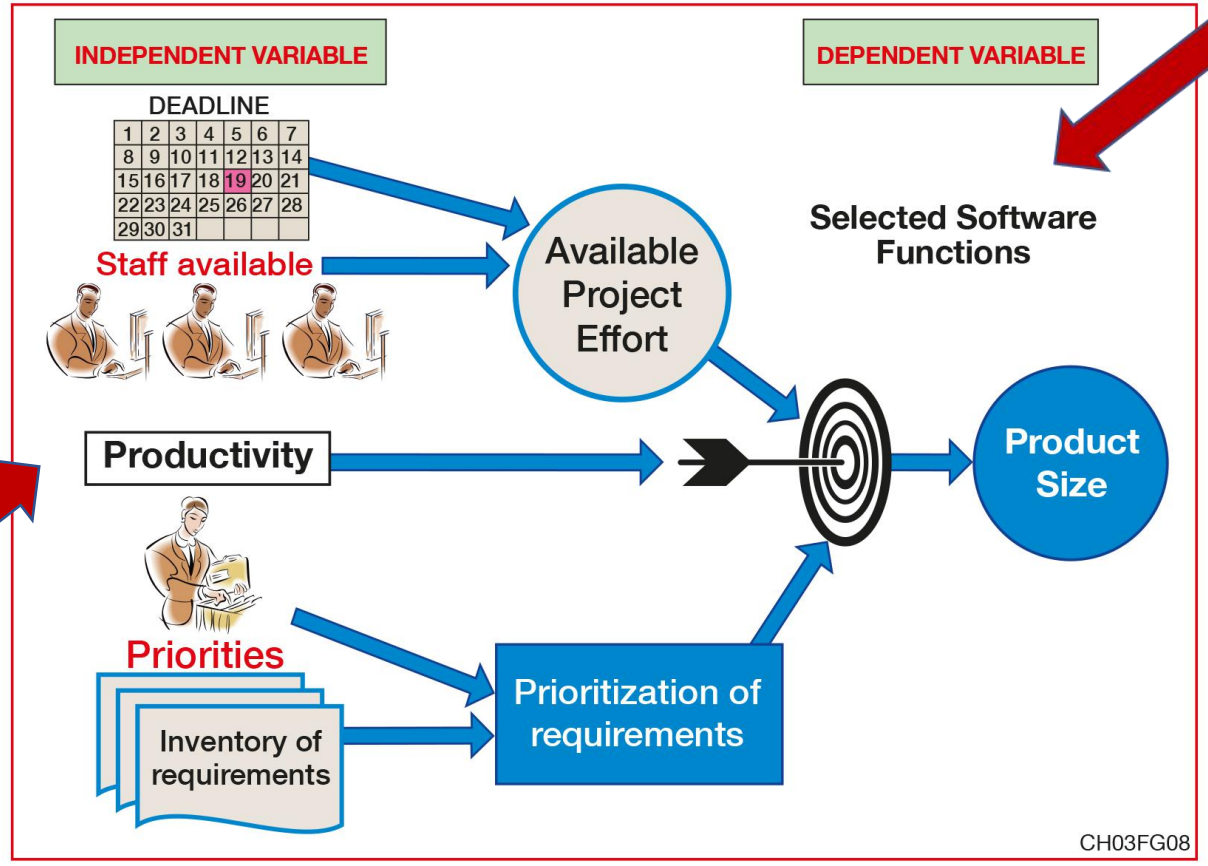
- List of requirements
- Priorities

What Product size to be delivered?

- with people available
- within the time frame

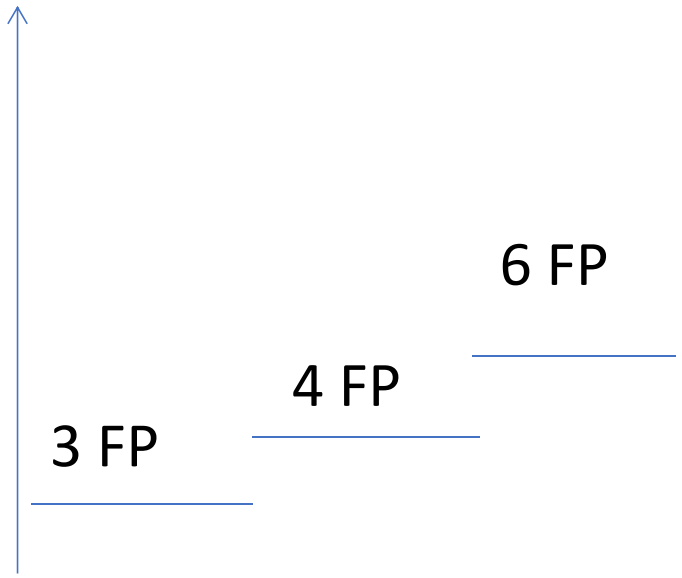
http://alwaysimages.it/i/choosing/

Agile Challenge: which software functions within the priorities & deadline?



1st Generation key weakness

Function Points weights =
Step functions

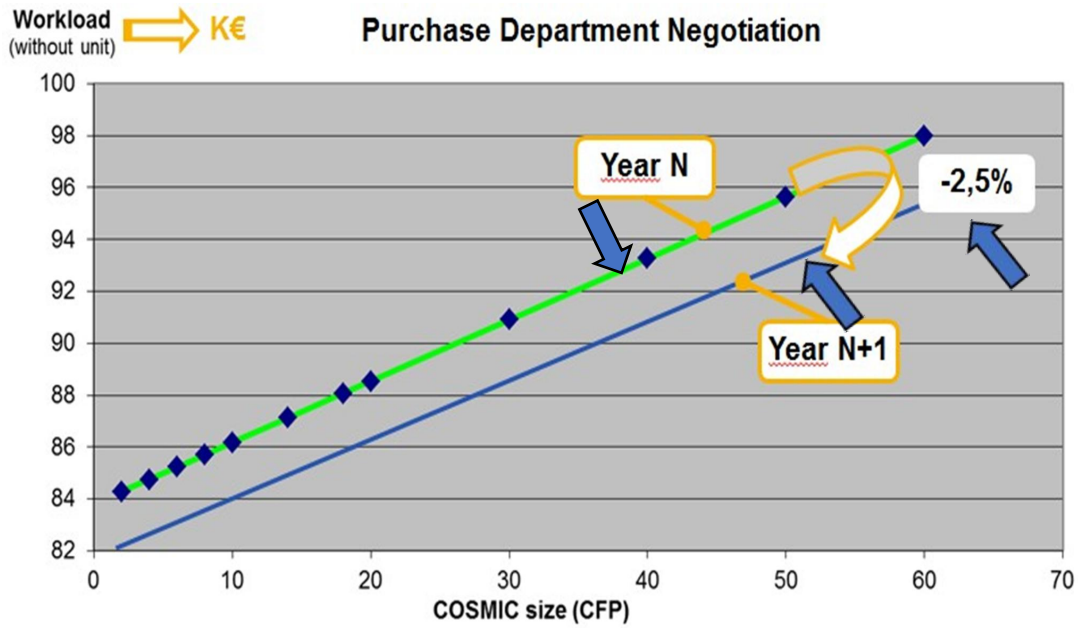


Key limitations:

- **Only 3 values**
- **Limited ranges (min,max)**
- **No single measurement unit of 1 FP!**

3-step size range - IFPUG External Input Transactions

Renault - Remarkable cost estimation accuracy from its ECU software specifications



Cost vs size (CFP)

M.I.T. study on COCOMO81 (Kemerer, 1987)

Small scale replication study - 17 projects

	Basic Exponential on Size	Intermediate & 15 cost drivers	Detailed & 4 project phases
R^2 (max=1.0)	**0.68**	**0.60**	**0.52**
Model Errors **(Mean magnitude of relative errors - MMRE)**	**610%**	**583%**	**607%**

Estimation Models with Machine Learning Techniques

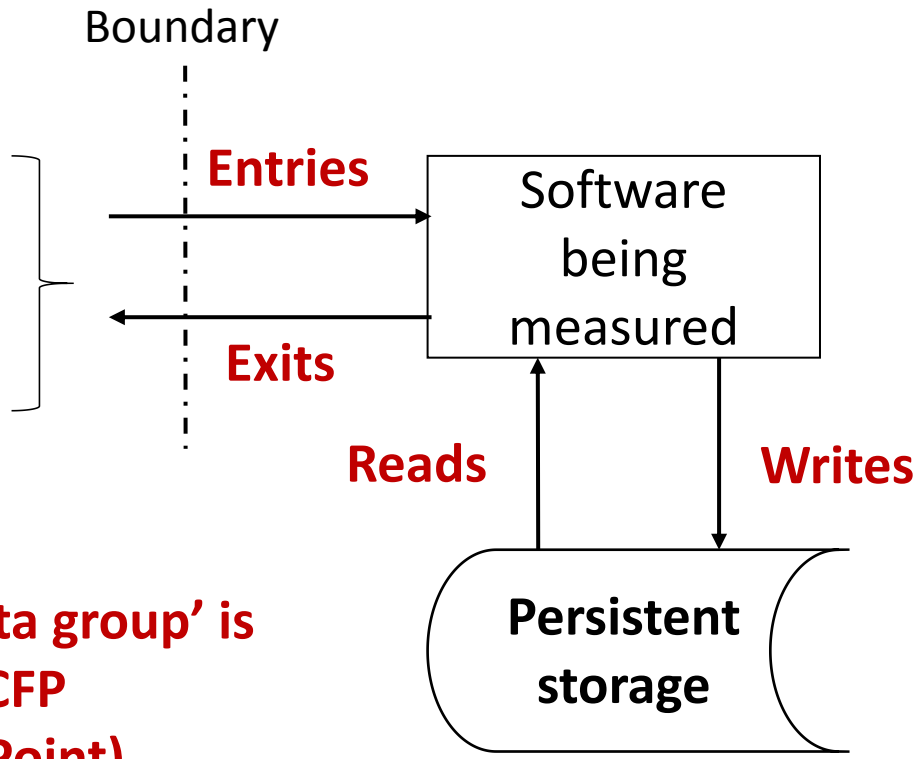
Table 1
Distribution of single techniques used to construct ensembles

Model		# of Studies	HM Ensemble	HT Ensemble
Artificial Neural Networks	MLP	9	13	3
	RBF	3	1	3
	ANN*	1	-	4
	TANN	1	-	1
	BPNN	1	-	1
	Total	**11**	**14**	**12**
Decision trees	M5P/ RT	1	1	-
	M5P/ MT	1	1	-
	RT	3	2	1
	MART	1	1	-
	CART	2	5	44
	M5P	1	-	1
	Bagging + Fast DT	1	-	1
	Random Subspace	1	-	1
	Decision Stump	1	-	1
	Additive Regression with Decision Stump	1	-	1
	Total	**8**	**10**	**54**
Case-Based Reasoning (CBR)		7	**45**	**28**
Support Vector Regression		**5**	**2**	**5**
Regression	Linear Regression	2	1	4
	MLR	1	-	1
	Total	**3**	**1**	**5**
Neuro Fuzzy	ANFIS	1	1	1
	DENFIS	1	-	1
	Total	**2**	**1**	**2**
Grey Relational Analysis		1	-	3
Decision Table		1	-	1
Conjunctive Rule		1	-	1
Locally Weighted		1	-	1
Gaussian Process		1	-	1

2nd Generation: COSMIC Function Points
All software does this:

Functional Users types:

1. Humans
2. Hardware devices
3. Other software



COSMIC view of software

The 'Data Movement of 1 data group' is the unit of measurement: 1 CFP (1 CFP = 1 COSMIC Function Point)

Latest Trends in Research

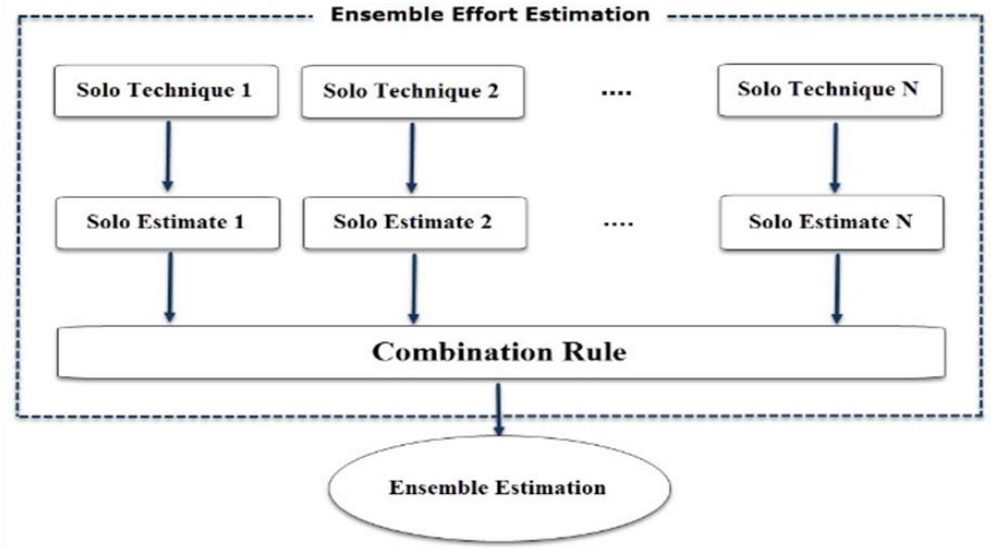


Fig. 1. Ensemble Effort Estimation (EEE) process.

Sources:

- 'Improved Estimation of Software Development Effort Using Classical & Fuzzy Analogy Ensembles', Idri, Hosni, Abran, Applied Soft Computing, Elsevier, vol. 49, 2016.
- 'On the value of parameter tuning in heterogeneous ensembles effort estimation', Hosni, Idri, Abran, Bou Nassif. In Soft Computing, Springer, 30 Nov. 2017, pp. 1-34

2nd Generation of Function Points

Every software is different, but …..

what is common across all software:

- In different types of software?
- In very small software?
- In very large software?
- In distinct software domains?
- In various countries?