CONGRESO NACIONAL DE MEDICIÓN Y ESTIMACIÓN DE SOFTWARE

Software Effort Estimating with COSMIC: Critical knowledge for today and tomorrow

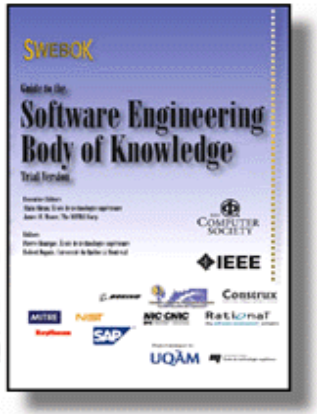
Alain Abran

with C.Symons, C.Ebert, F.Vogelezang, H.Soubra

Presenter background - Alain Abran

20 years

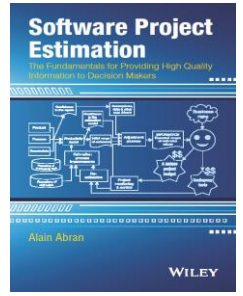
- **Development**
- **Maintenance**
- **Process Improvement**

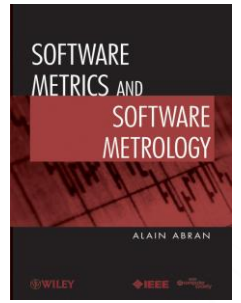


20 years

+ 40 PhD

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

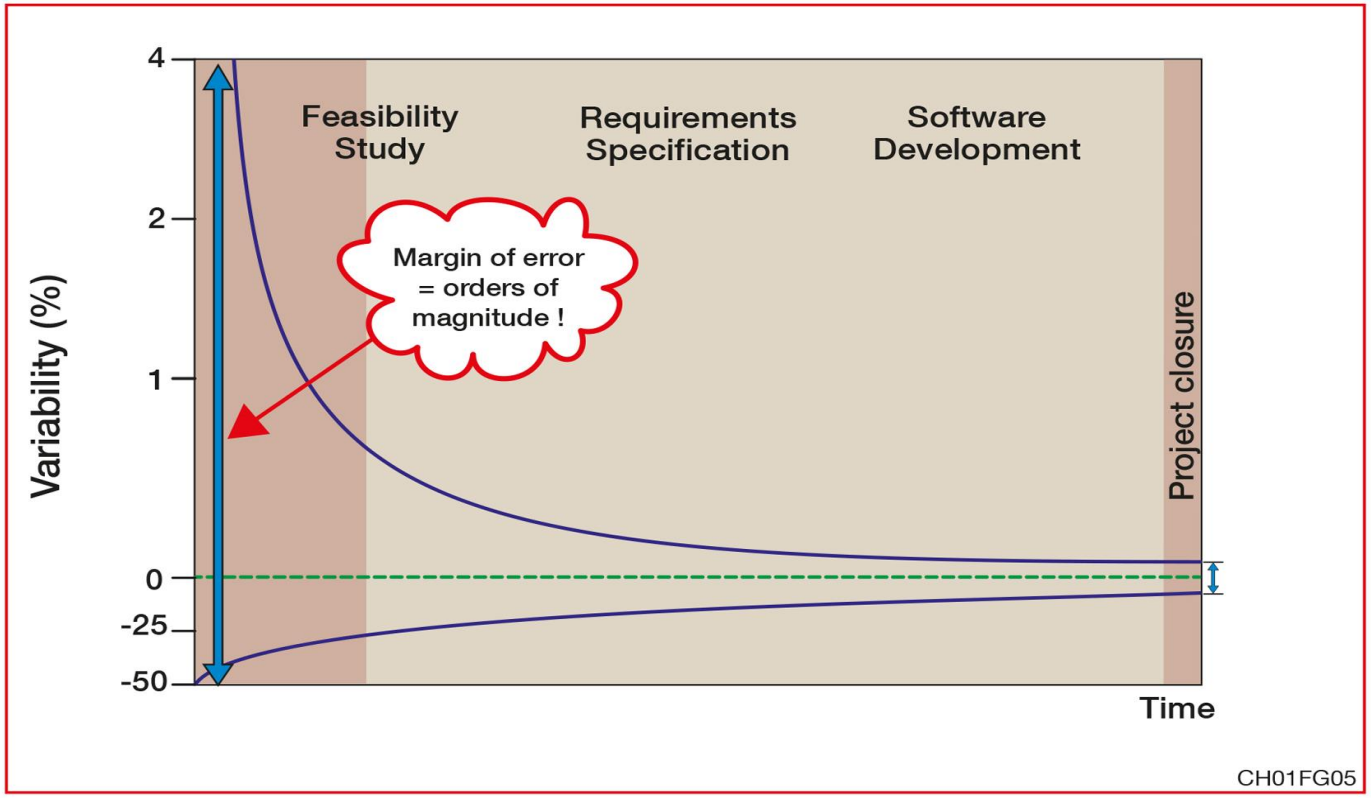




Agenda

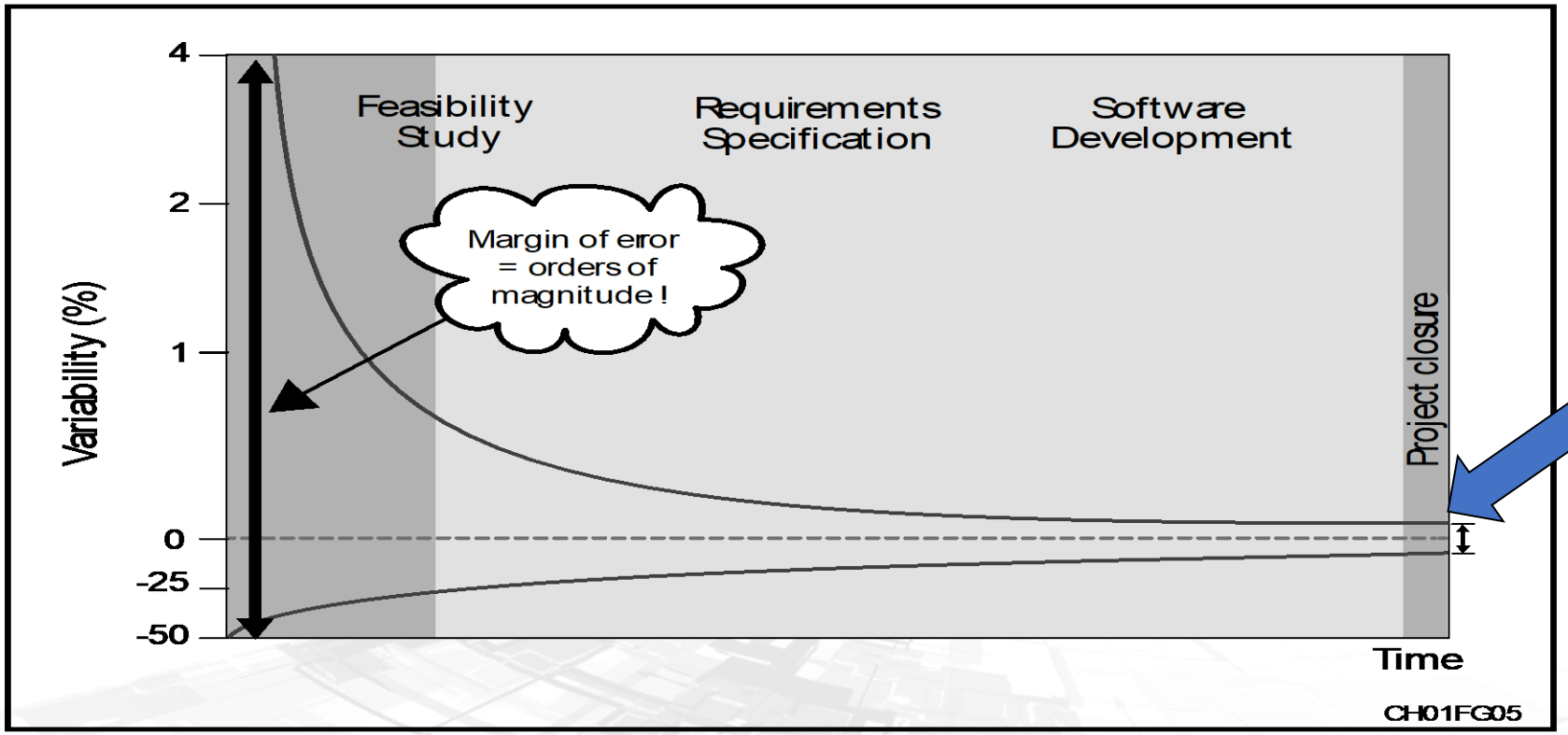
1. Software effort estimation & software size
2. COSMIC: 2nd generation of Function Points
3. Versatility of COSMIC Function Points
4. Contributions of COSMIC to Estimation models
5. Early & Quick COSMIC sizing at estimation time
6. Summary

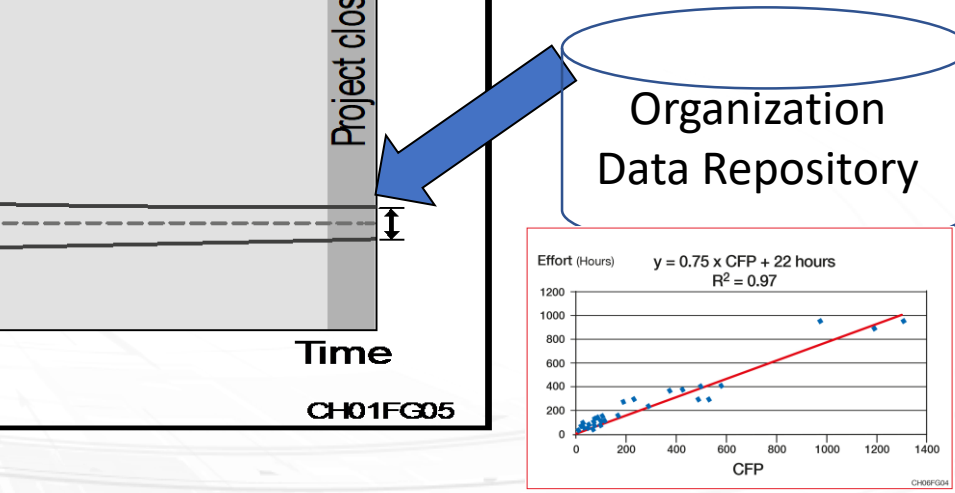
The Cone of Uncertainty across the Project Lifecycle



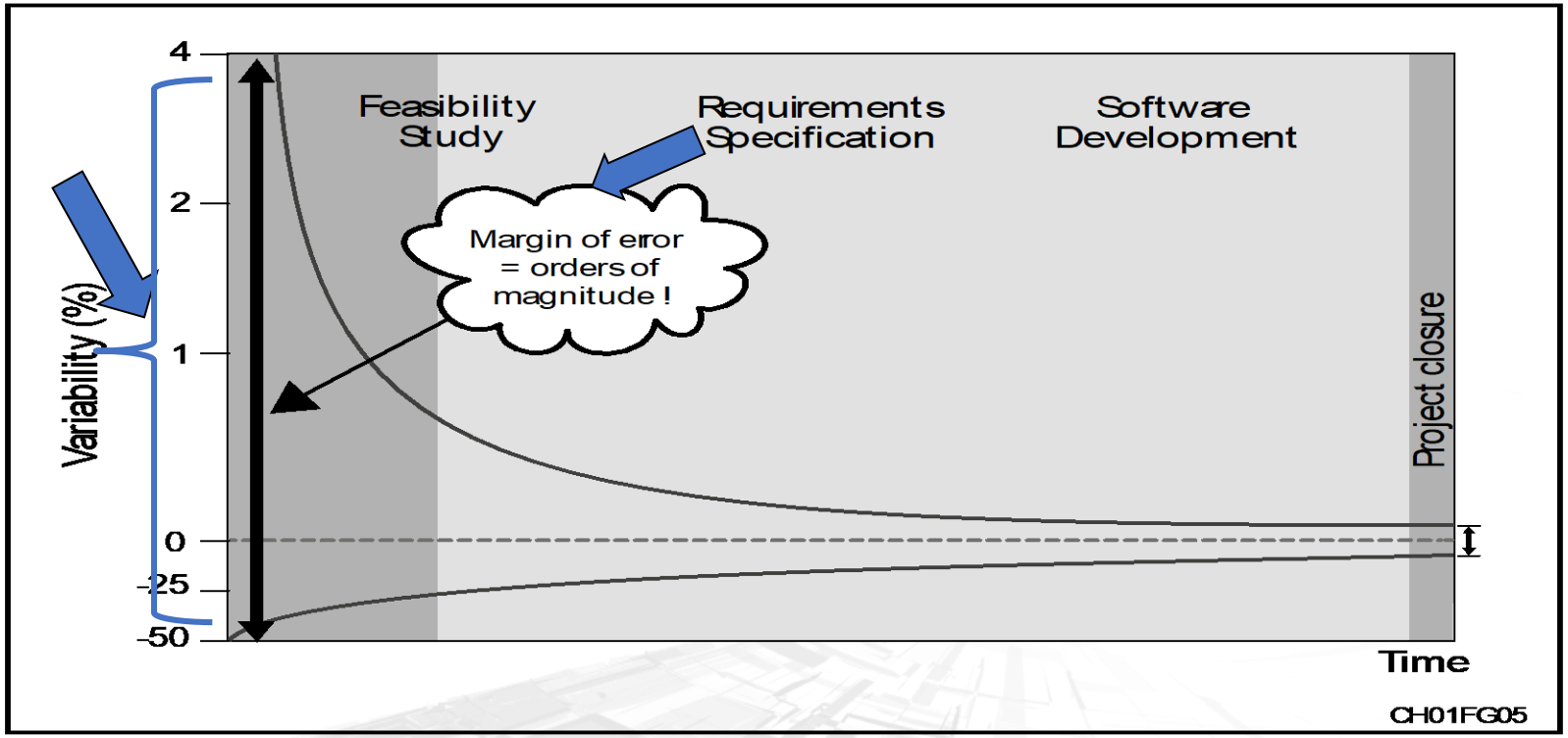
Range of expected variations in 'estimation' models across the project life cycle

Adapted from Boehm (2000), Fig. 1.2

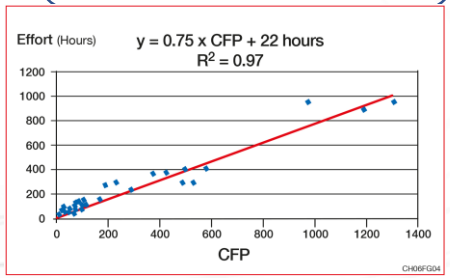




You build estimation models with completed projects (with almost no uncertainty in the inputs)

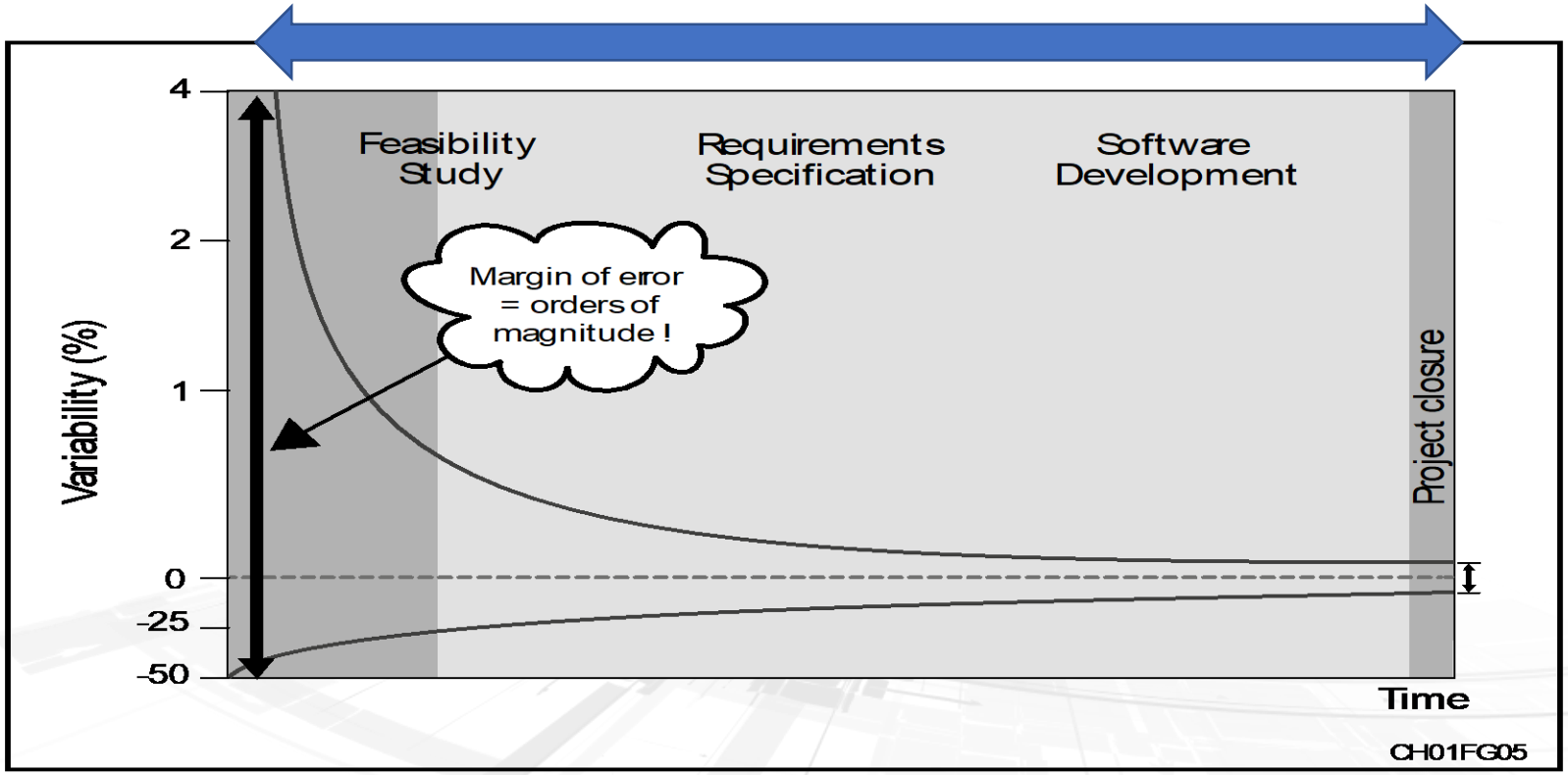


Organization Data Repository



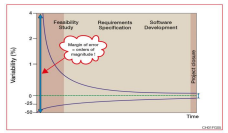
- **You do estimation upfront with a lot of uncertainty**

What is Available & Measurable Across the Software Lifecycle?



Software Sizing Options across the Lifecycle?

- Lines of code:
  - X Can't estimate until software designed
  - X Technology-dependent, no standards



- Usecase Points, Object Points, ..
  - X Technology dependent, no standards
  - X Mathematical validity?

- Story Points
  - X Entirely subjective

- Functional size
  - ✓ (Function Points):
    - ✓ International standard methods
    - ✓ Technology-independent

ISO International Organization for Standardization

Agenda

1. Software Effort Estimation & Software Size
2. COSMIC: 2nd generation of Function Points
3. Versatility of COSMIC Function Points
4. Contributions of COSMIC to Estimation models
5. Early & Quick COSMIC sizing at estimation time
6. Summary

1st Generation of Function Points = Complexity tables & Weights

FTR's	DATA ELEMENTS		
	1-4	5-15	> 15
0-1	Low	Low	Ave
2	Low	Ave	High
3 or more	Ave	High	High

Inputs - Matrix

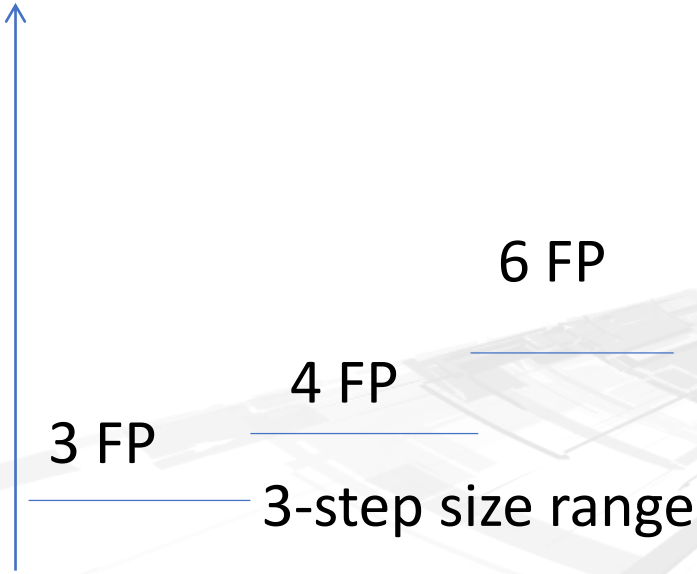
FTR's	DATA ELEMENTS		
	1-5	6-19	> 19
0-1	Low	Low	Ave
2-3	Low	Ave	High
> 3	Ave	High	High

Output & Enquiries – Shared Matrix

Rating	VALUES		
	EO	EQ	EI
Low	4	3	3
Average	5	4	4
High	7	6	6

Transactions: weights in FP (Function Points)

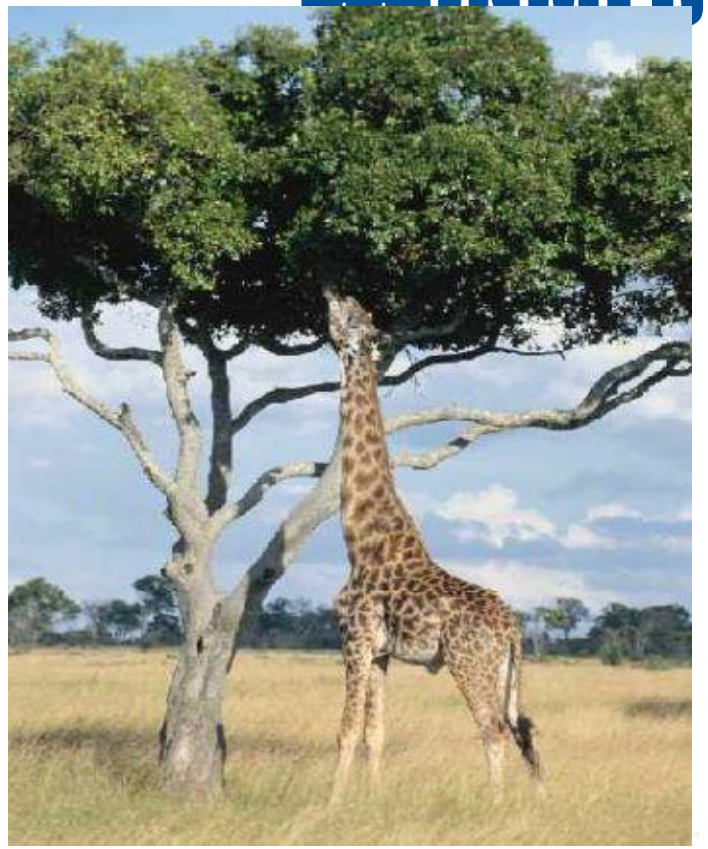
Function Points weights =
Step functions



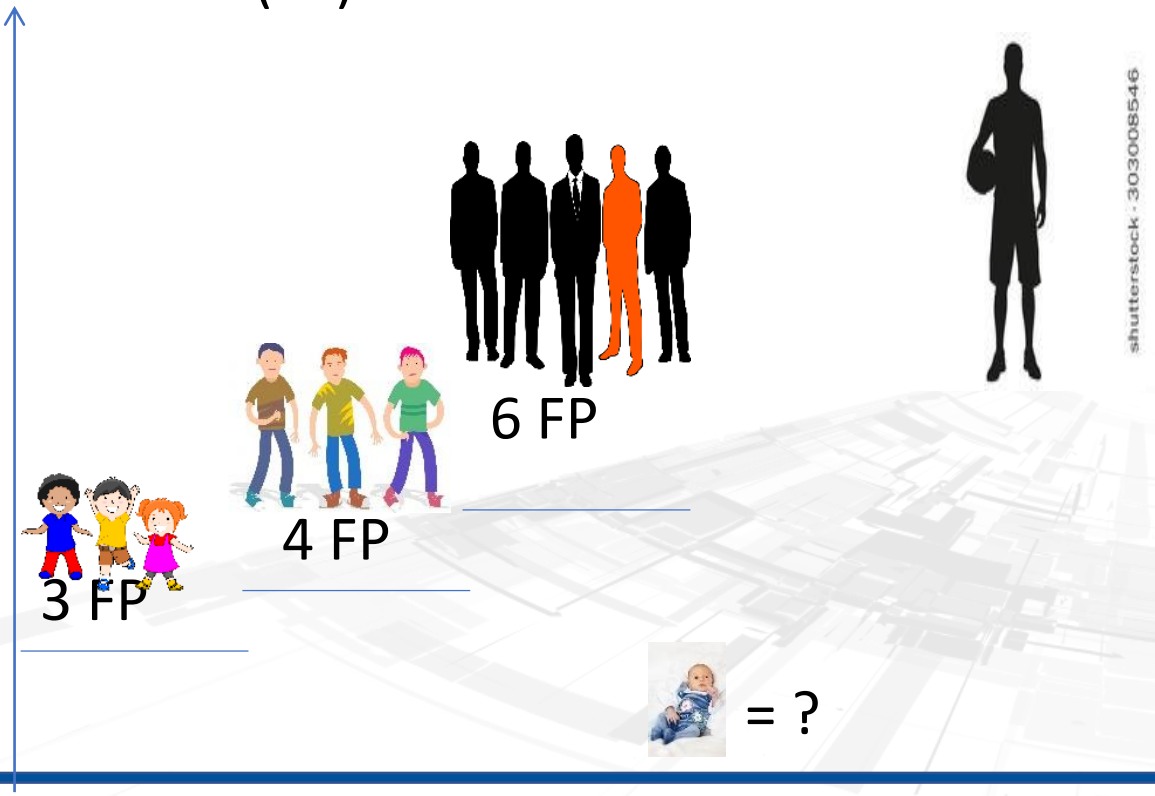
Key limitations:

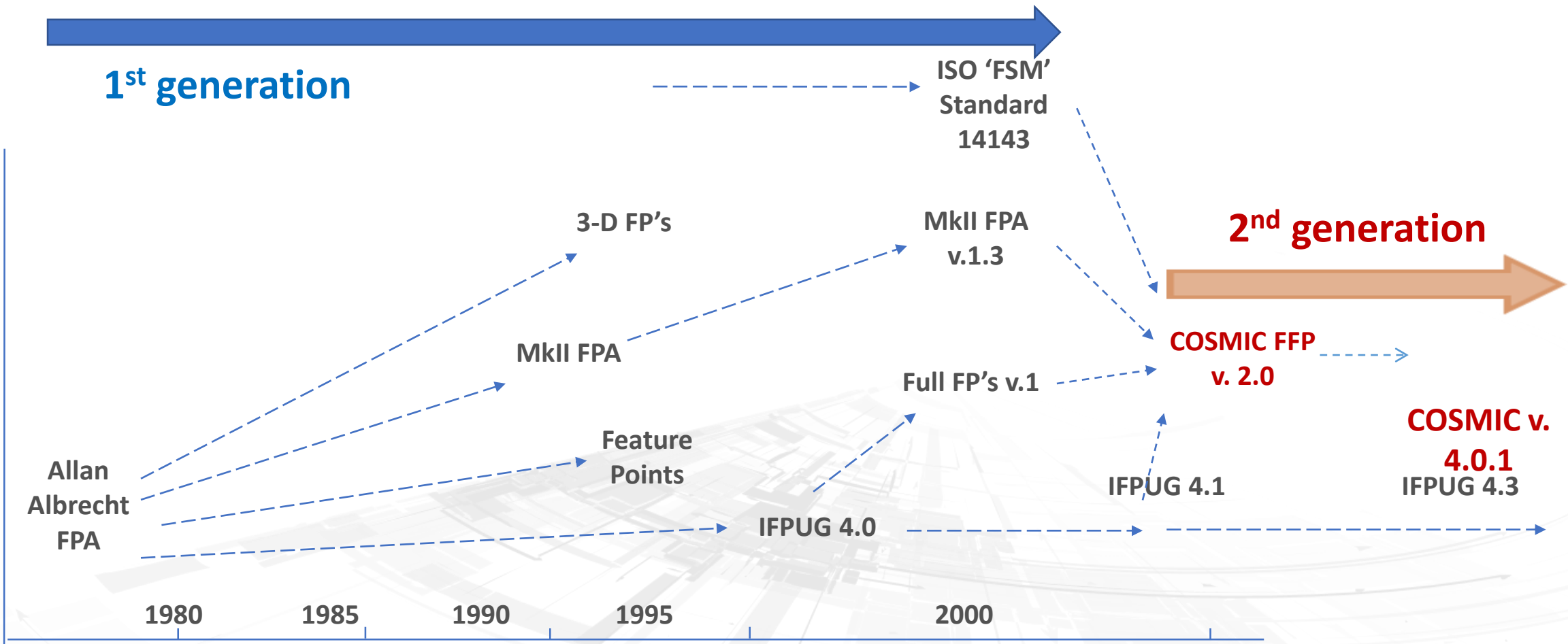
- **Only 3 values**
- **Limited ranges (min,max)**
- **No single measurement unit of 1 FP!**

1st Generation of Function Points



Function Points (FP)





2nd Generation of Function Points

Every software is different, but …..

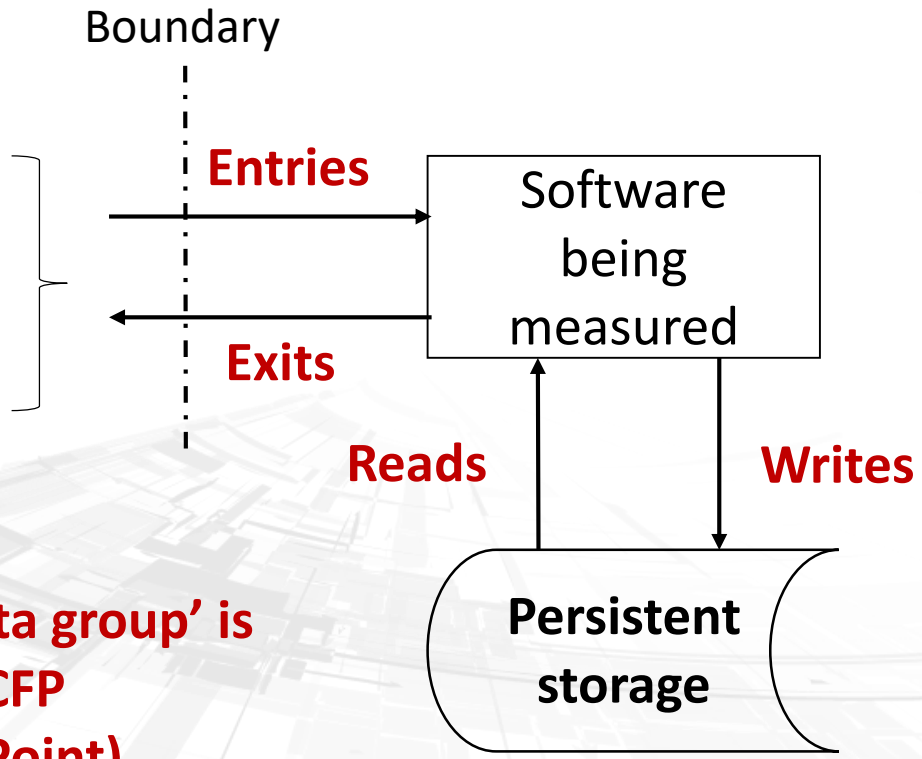
what is common across all software:

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

2nd Generation of Function Points
All software does this:

Functional Users types:

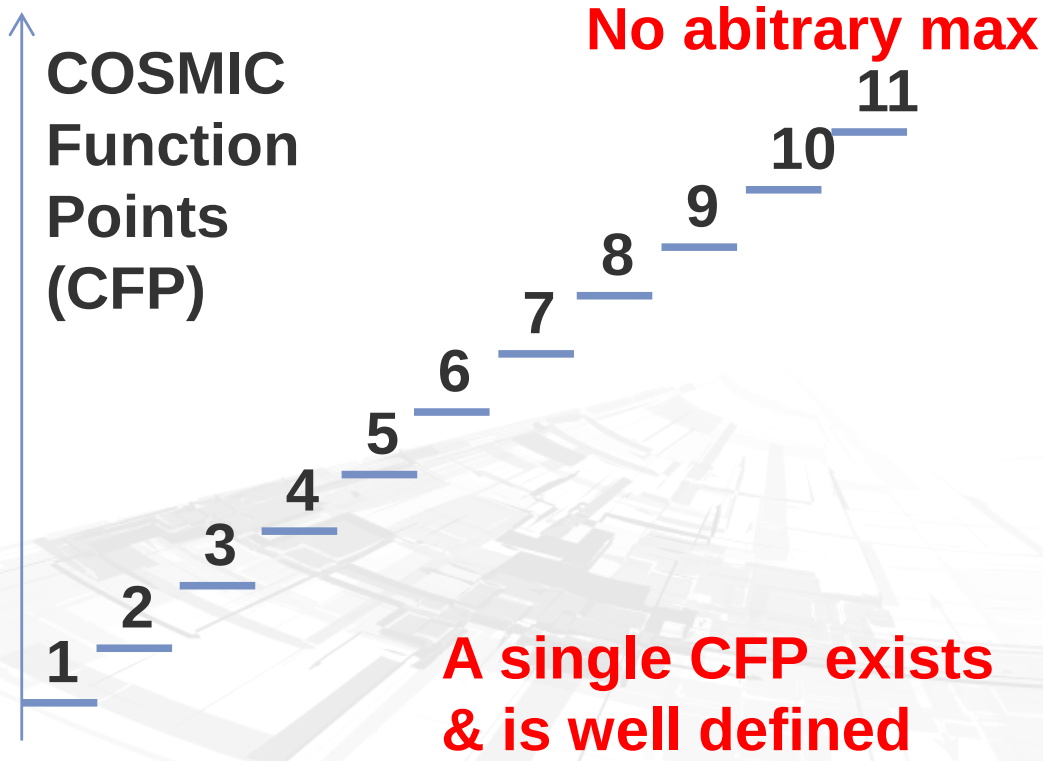
1. Humans
2. Hardware devices
3. Other software



COSMIC view of software

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

2nd Generation with COSMIC

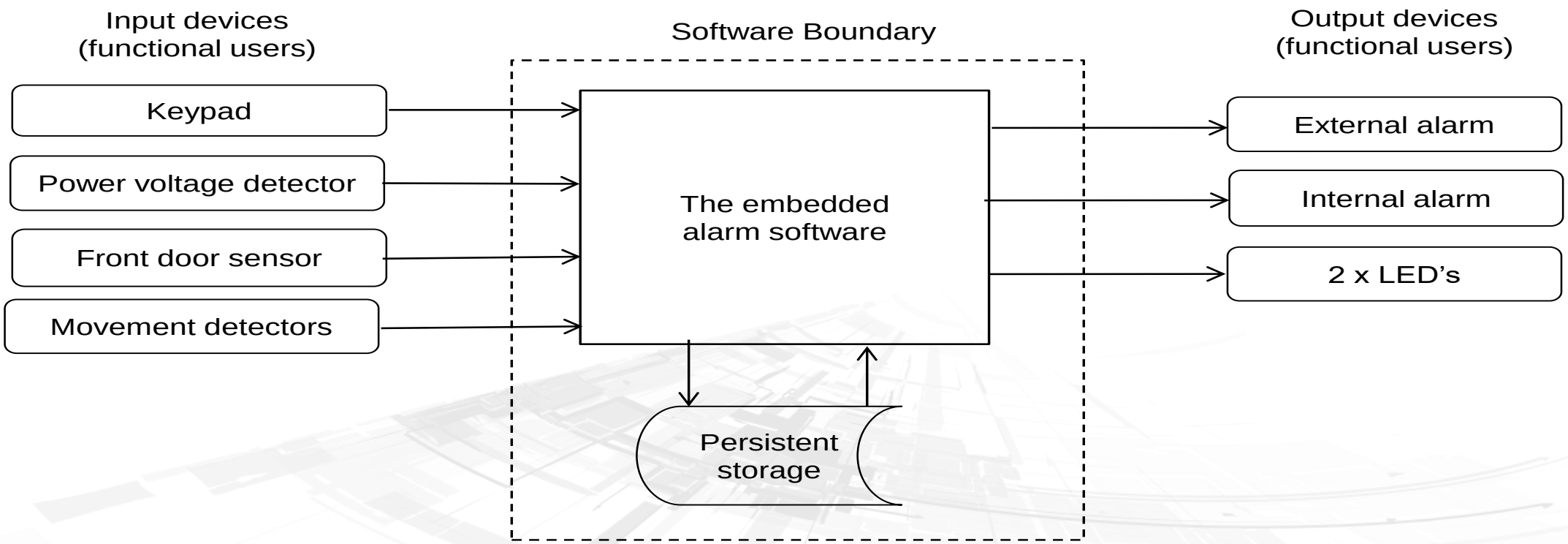


Largest observed functional processes:

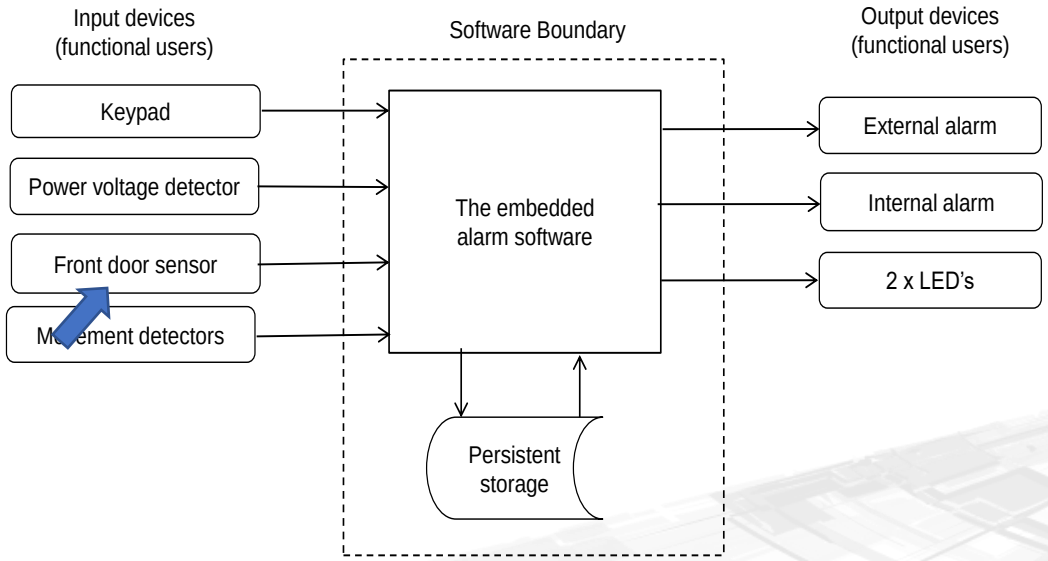
In avionics >100 CFP

In banking > 70 CFP

Example 1: Intruder Alarm System - Requirements



Functional process: Possible intruder detected.
Triggering event: Door opens whilst alarm system is activated.



Data Movement	Functional User	Data Group
Entry	Front-door sensor	'Door open' message (triggering Entry)
Read	- / Occupant	PIN (from persistent storage)
Exit	Green LED	Switch 'off' command
Exit	Red LED	Switch 'on' command
Exit	Internal siren	Start noise command
Entry	Keypad	PIN (If the wrong code is entered, the user may enter the PIN two more times but the process is always the same so it is only measured once.)
*	Green LED	Switch 'on' command (after successful entry of PIN)
*	Red LED	Switch 'off' command
Exit	Internal siren	Stop noise command (after successful entry of PIN)
Exit	External siren	Start noise command (after three unsuccessful PIN entries, or if the PIN is not entered in time)
Exit	External siren	Stop noise command (after 20 minutes, a legal requirement)

Size = 9 CFP (COSMIC Function Points)

Agenda

1. Software Effort Estimation & Software Size
2. COSMIC: 2nd generation of Function Points
3. **Versatility of COSMIC Function Points**
4. Contributions of COSMIC to Estimation Models
5. Early & Quick COSMIC sizing at Estimation Time
6. Summary

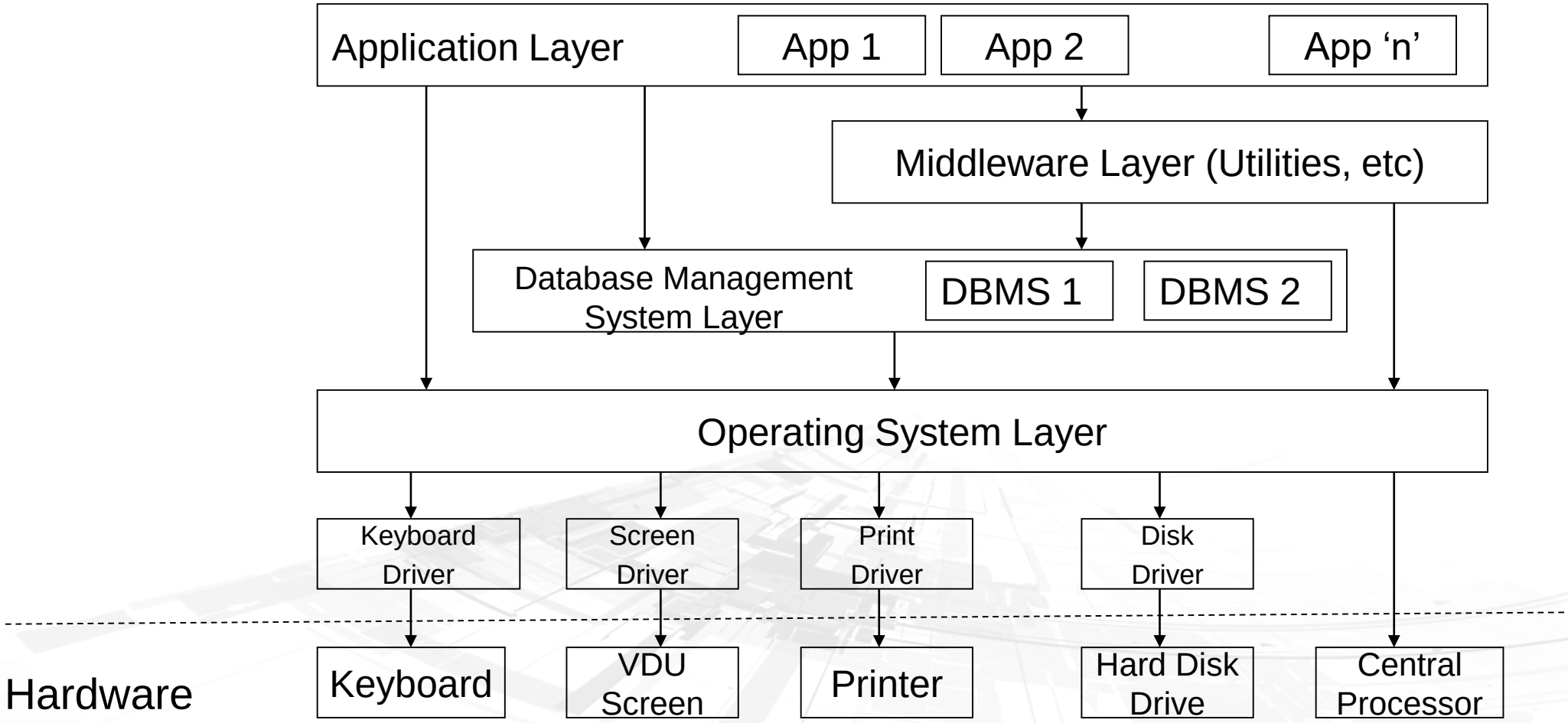
Versatility - Guidelines by Application Domains

- Business applications
- Real-time software
- Data Warehouse software
- SOA software (SOA: Service Oriented Architecture)
- Mobile apps
- Agile Development

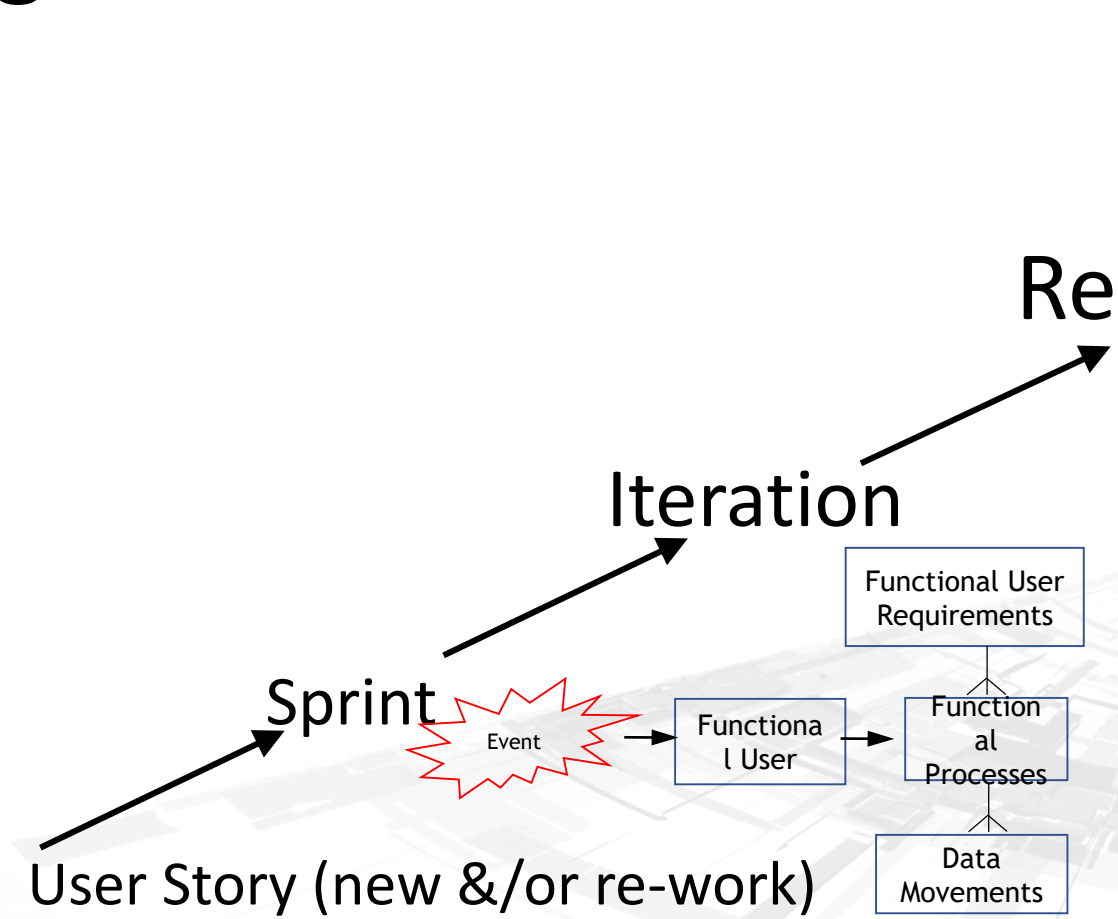
Versatility – COSMIC Case Studies

- Real-time:
  - Rice cooker
  - Automatic line switching
  - Valve control
- Business:
  - Course registration (distributed)
  - Restaurant management (web & mobile phone)
  - Banking web advice module
  - Car hire (existing legacy app.)

Versatility - at any level of software requirements



Agile: COSMIC Aggregation rules



COSMIC size usable for:

- early Total System sizing & effort estimation
- US, Sprint etc. sizing & estimation
- Progress control at any level

Agenda

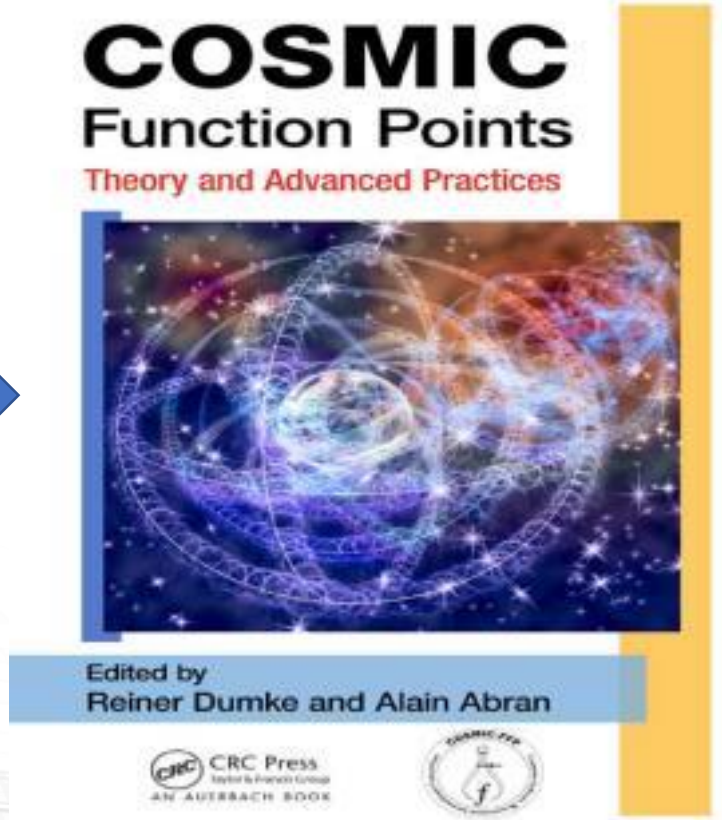
1. Software Effort Estimation & Software Size
2. COSMIC: 2nd generation of Function Points
3. Versatility of COSMIC Function Points
4. **Contributions of COSMIC to Estimation models**
5. Early & Quick COSMIC sizing at estimation time
6. Summary

COSMIC data from Industry

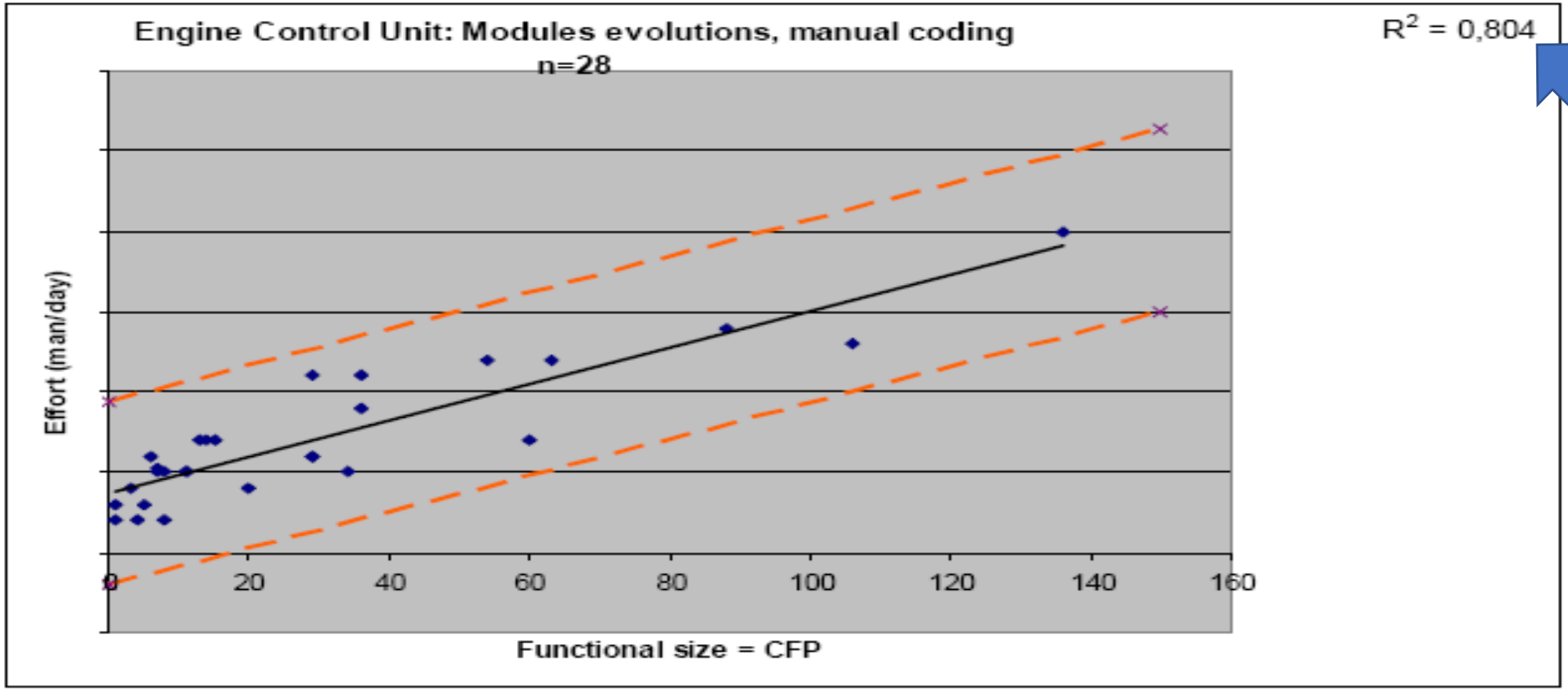
COSMIC method in Automotive embedded software

By: Sophie Stern

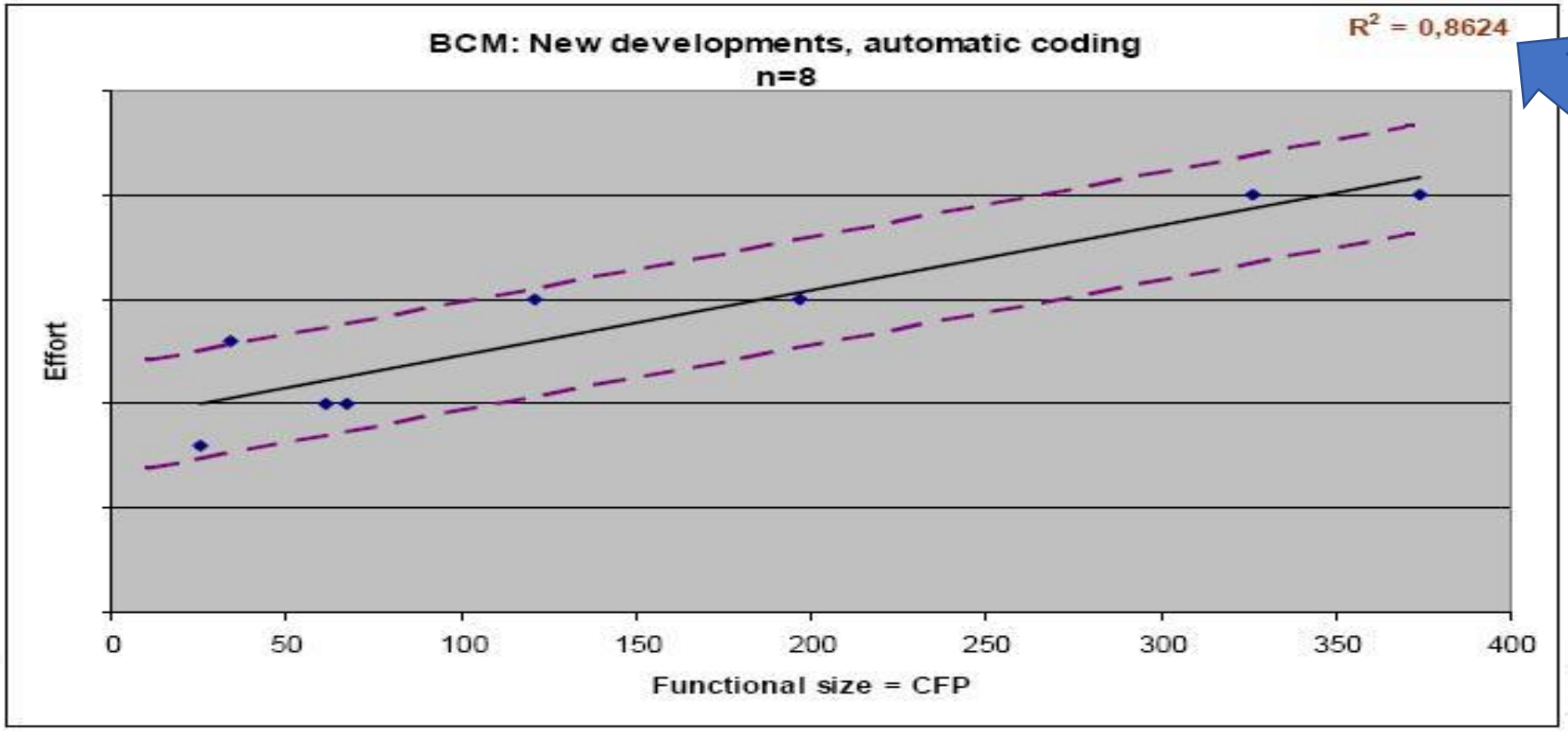
Renault



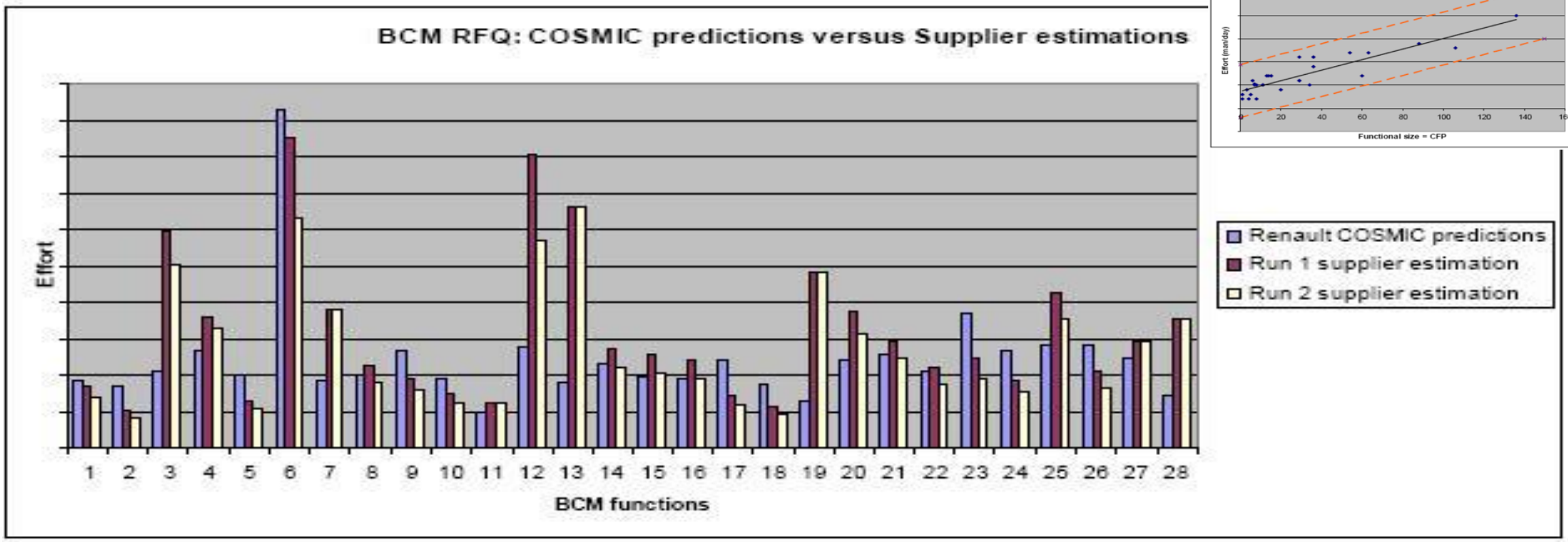
Data from Renault - 2012



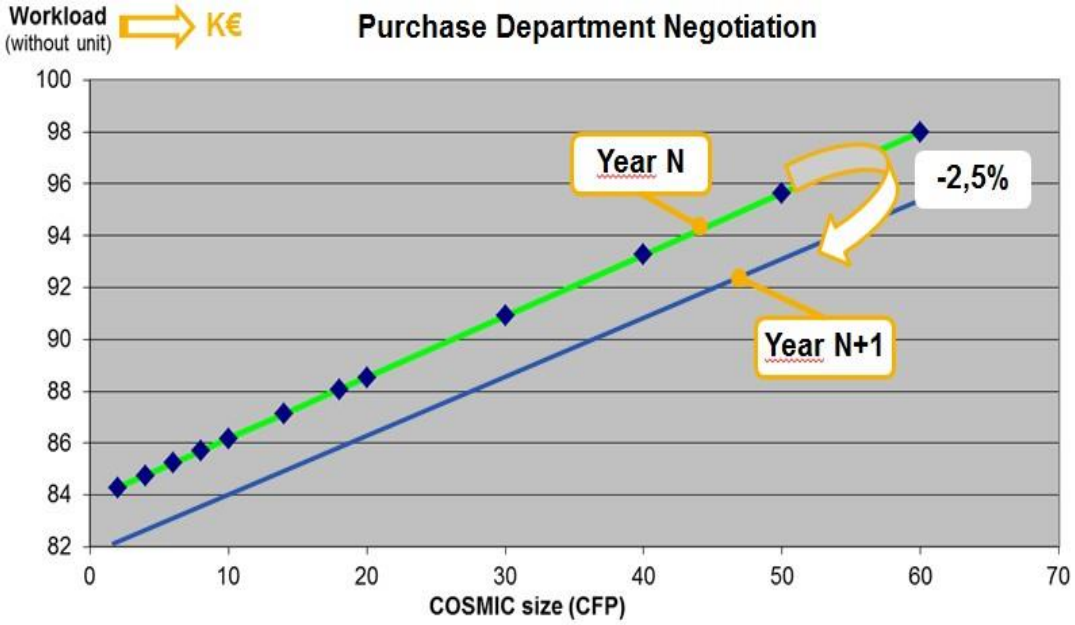
Data from Renault – 2012



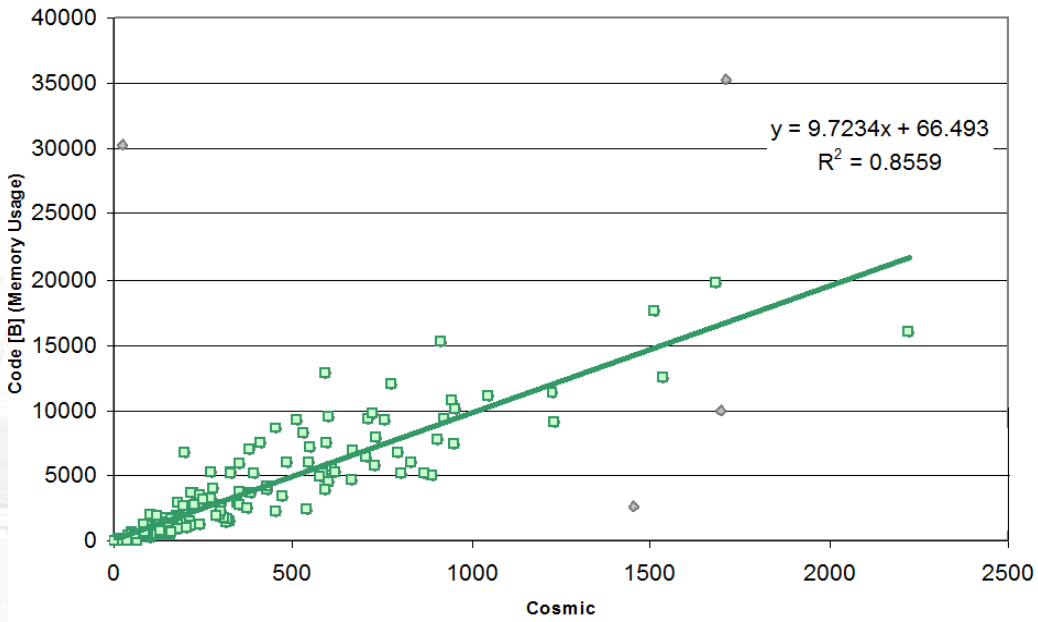
Renault: Estimation & Negociations



Renault - Remarkable cost estimation accuracy from its ECU software specifications

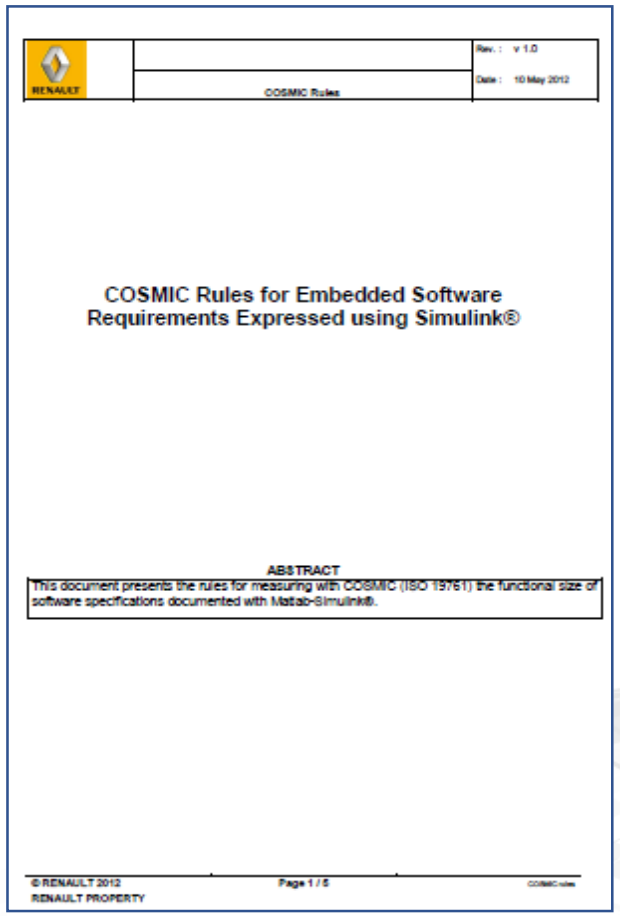


Cost vs size (CFP)



Memory size vs software size (CFP)

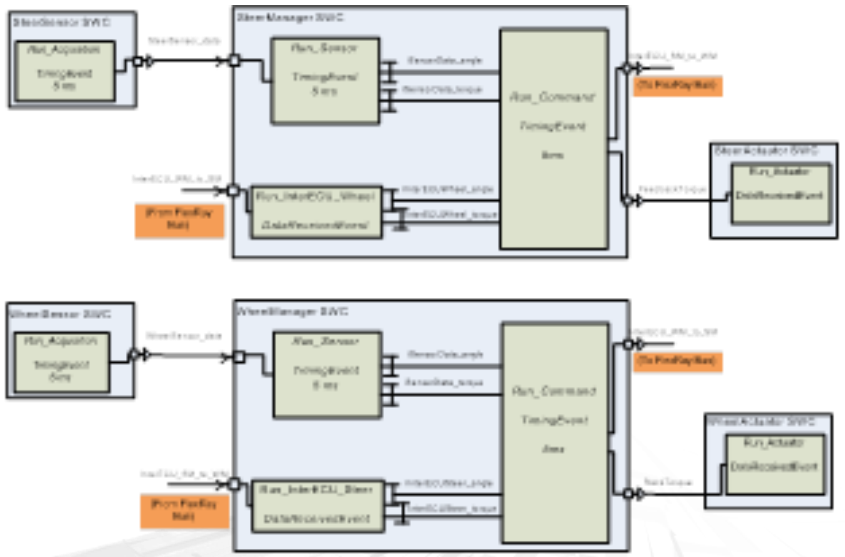
Renault: COSMIC Automation with Matlab SIMULINK

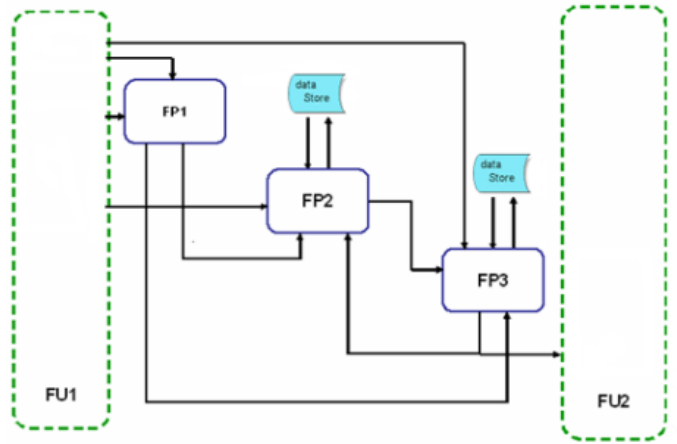


COSMIC Rules for Embedded Software Requirements Expressed using Simulink®

ABSTRACT

This document presents the rules for measuring with COSMIC (ISO 19761) the functional size of software specifications documented with Matlab-Simulink®.





Ref. H. Soubra, and K. Chaaban, "Functional Size Measurement of Electronic Control Units Software Designed Following the AUTOSAR Standard: A Measurement Guideline Based on the COSMIC ISO 19761 Standard," IWSM-MENSURA Conference, Assisi (Italy), IEEE CS Press, 2012.

AUTOMATION ACCURACY REACHED WITH COSMIC

Steer-by-wire case study

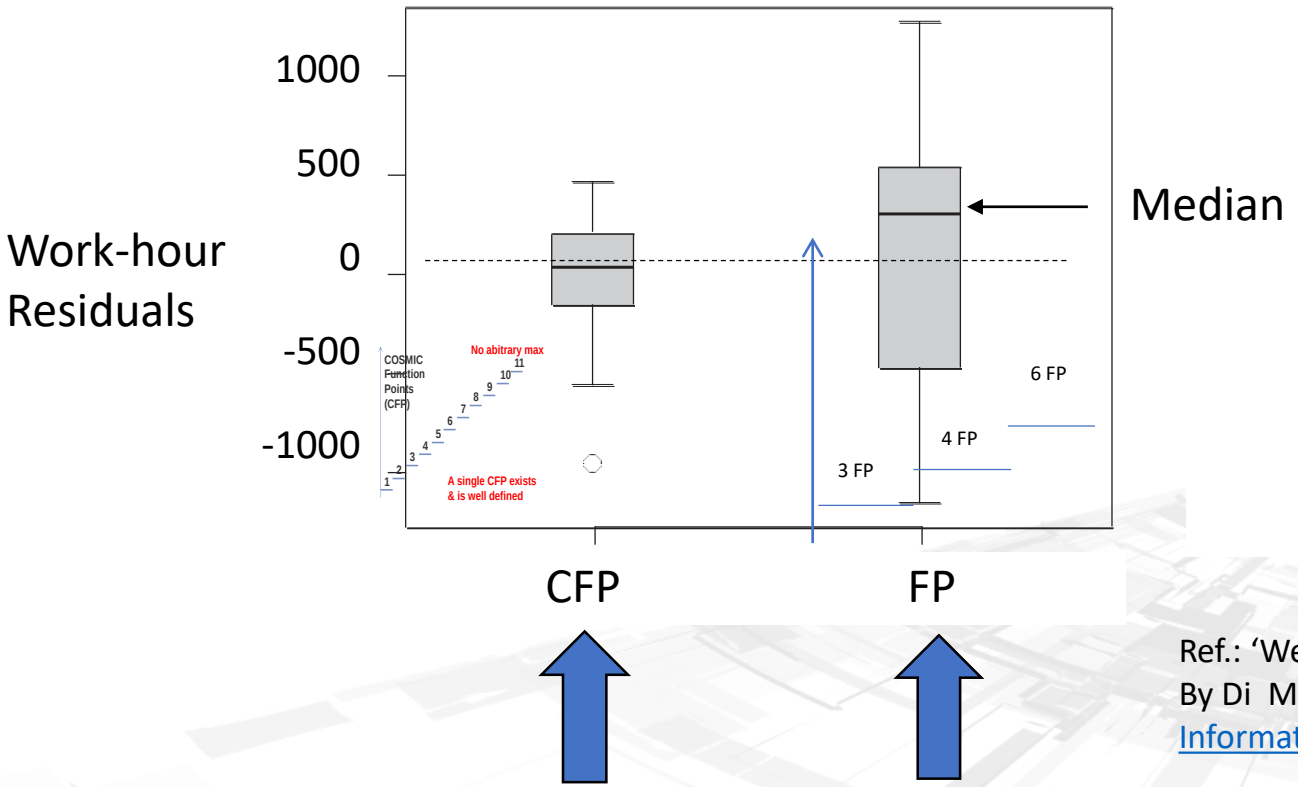
Steer-by-Wire Runnable	Functional size obtained by the manual FSM procedure (CFP)	Functional size obtained by the automated FSM procedure (CFP)
Steer_Run_Acquisition	3	3
Steer_Run_Sensor	4	4
Steer_Run_Command	7	7
Steer_InterECU_Wheel	3	3
Steer_Run_Actuator	2	2
Wheel_Run_Acquistion	3	3
Wheel_Run_Sensor	4	4
Wheel_Run_Command	7	7
Wheel_InterECU_Steer	3	3
Wheel _Run_Actuator	2	2
Total	**38**	**38**

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.

Industry Data – Example 2



25 industrial Web applications

Conclusions:

'The results of the … study revealed that COSMIC outperformed Function Points as indicator of development effort by providing significantly better estimations'

Ref.: 'Web Effort Estimation: Function Point Analysis vs. COSMIC
By Di Martino, Ferrucci, Gravino, Sarro,
Information and Software Technology 72 (2016) 90–109

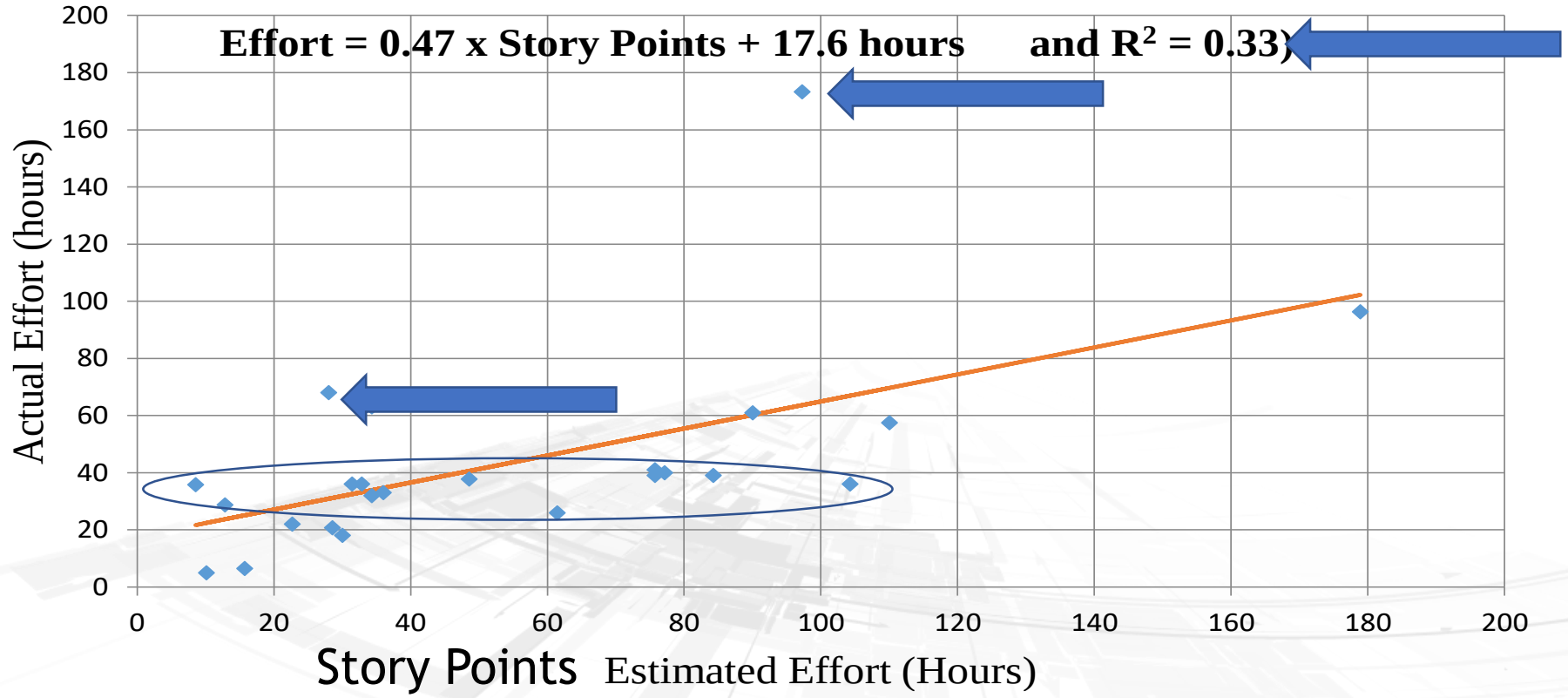
Industry Data – Example 3: Security & surveillance software systems

Context:

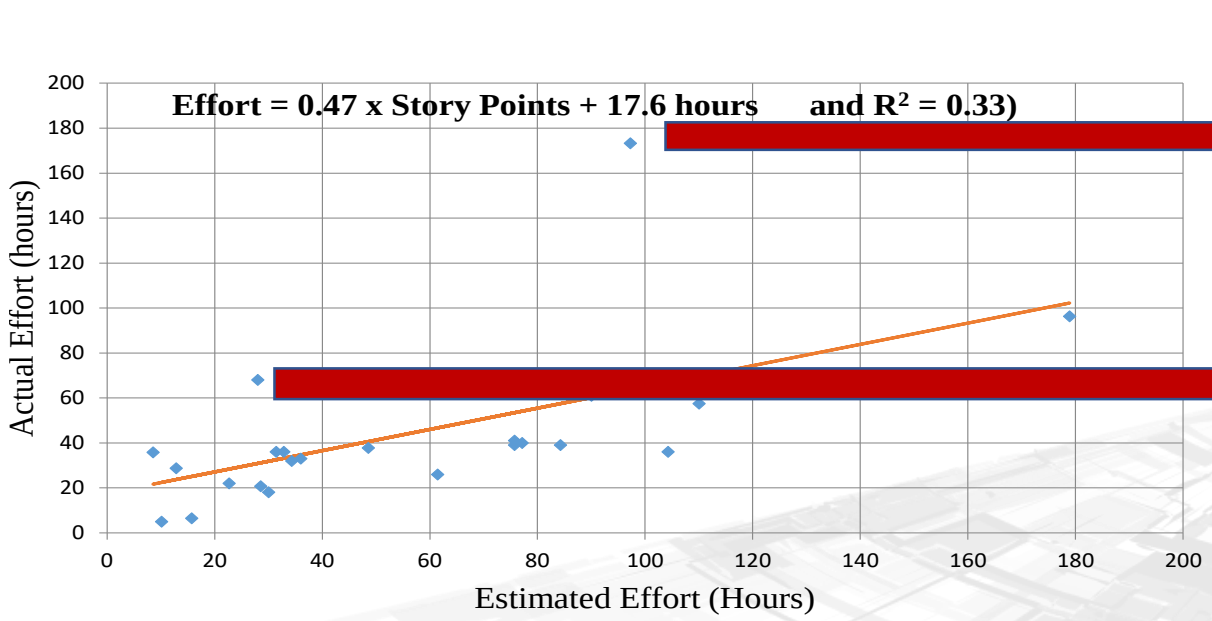
- Scrum method
- Teams estimate tasks within each iteration in Story Points
- Measurements of 24 tasks in 9 iterations
  - Each task estimated in Story Points
  - Task actual effort recorded
  - Each task also measured in CFP

Ref. 'Effort Estimation with Story Points and COSMIC Function Points - An Industry Case Study',
C. Commeyne, A. Abran, R. Djouab. Obtainable from www.cosmic-sizing.org 'Software Measurement News'. Vol 21, No. 1, 2016

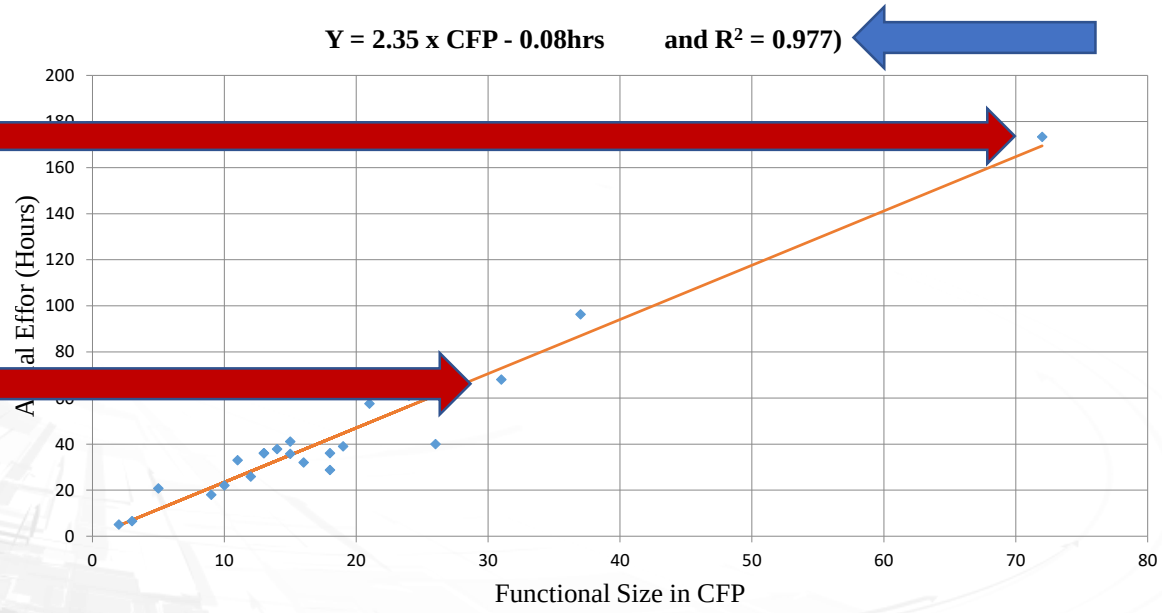
Industry Data – Example 3: Security & surveillance software systems



Industry Data – Example 3: Security & surveillance software systems



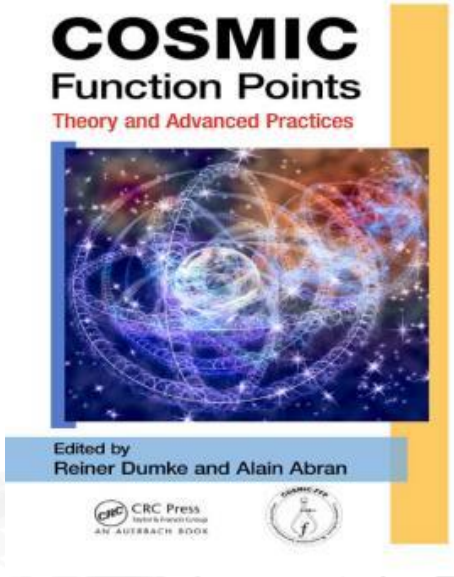
Story Points

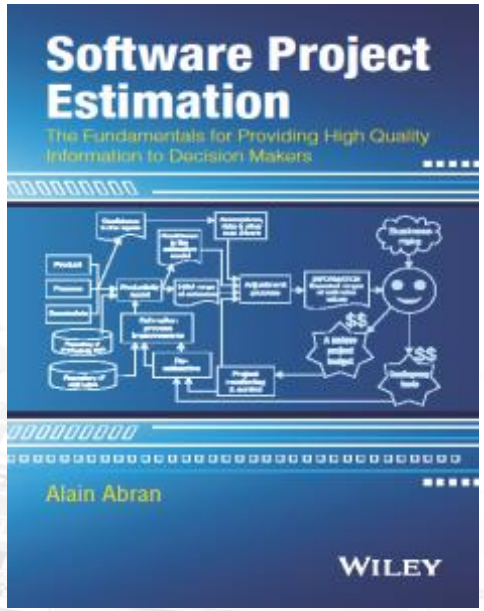


COSMIC

Other sources of COSMIC examples with industry data

- COSMIC web site at: www.cosmic-sizing.org

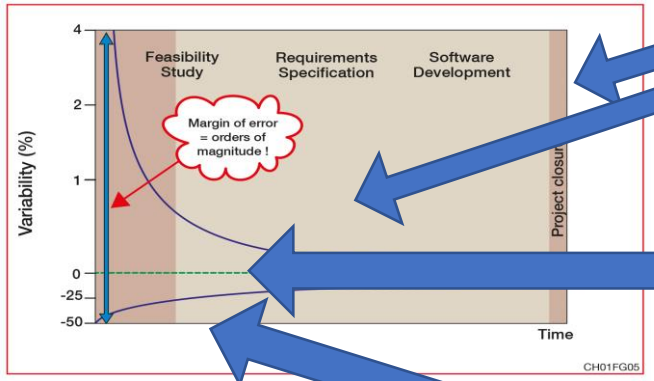




Agenda

1. Software Effort Estimation & Software Size
2. COSMIC: 2nd generation of Function Points
3. Versatility of COSMIC Function Points
4. Contributions of COSMIC to Estimation models
5. **Early & Quick COSMIC sizing at estimation time**
6. Summary

Quality of the documentation of a functional process at measurement time

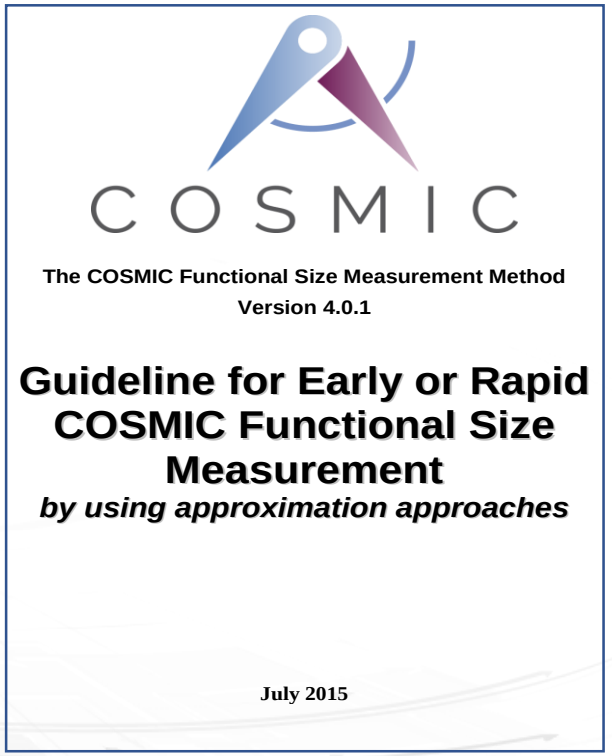


Functional Process Quality Level	Quality of the functional process definition
Completely defined	Functional process and its data movements are completely defined
Documented	Functional process is documented but not in sufficient detail to identify the data movements
Identified	Functional process is listed but no details are given of its data movements
Counted	A count of the functional processes is given, but there are no more details[3]
Implied (A 'known unknown')	The functional process is implied in the actual requirements but is not explicitly mentioned
Not mentioned (An 'unknown unknown')	Existence of the functional processes is completely unknown at present

COSMIC Guidelines for Early or Rapid sizing

Presents 8 approximation techniques
(including reported use, strengths & weaknesses):

1. Average functional process approximation
2. Fixed size classification approximation
3. Equal size bands approximation
4. Average use case approximation
5. Early & quick COSMIC approximation
6. Easy function points approximation
7. Approximation from informally written texts
8. **Approximation using fuzzy logic - EPCU**

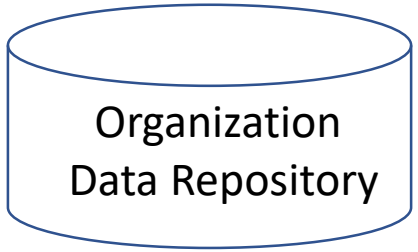


Example 1: Fixed size intervals

Classification	Size (CFP)	#E	#X	#R	#W	Error messages
Small	5	1	1	1	1	1
Medium	10	2	2	3	2	1
Large	15	3	3	4	4	1
…						

Example 2: Equal size bands

Equal size bands from 37 business applications



Band	.Average size of a Functional Process	% of total Functional Size	% of total number of Functional Processes
Small	4.8	25%	40%
Medium	7.7	25%	26%
Large	10.7	25%	19%
Very Large	16.4	25%	15%

Equal size bands from a major component of an avionics system

Band	Average size of a Functional Process	% of total Functional Size	% of total number of Functional Processes
Small	5.5	25%	49%
Medium	10.8	25%	26%
Large	18.1	25%	16%
Very Large	38.8	25%	7%

Example 3: Probability distribution in the Business domain

Classification of the FP	Specification level	CFP (min)	CFP	CFP (max)	Approximate CFP	Probability
Small FP	Little unknown	2 (10%)	3 (75%)	5 (15%)	3.2	>80%
Small FP	Unknown (No FUR)	2 (15%)	4 (50%)	8 (35%)	5.1	<50%
Medium FP	Little unknown	5 (10%)	7 (75%)	10 (15%)	7.25	>80%
Medium FP	Unknown (No FUR)	5 (15%)	8 (50%)	12 (35%)	8.95	<50%
Large FP	Little unknown	8 (10%)	10 (75%)	12 (15%)	10.1	>80%
Large FP	Unknown (No FUR)	8 (15%)	10 (50%)	15 (35%)	11.45	<50%
Complex FP	Little unknown	10 (10%)	15 (75%)	20 (15%)	15.25	>80%
Complex FP	Unknown (No FUR)	10 (15%)	18 (50%)	30 (35%)	21	<50%

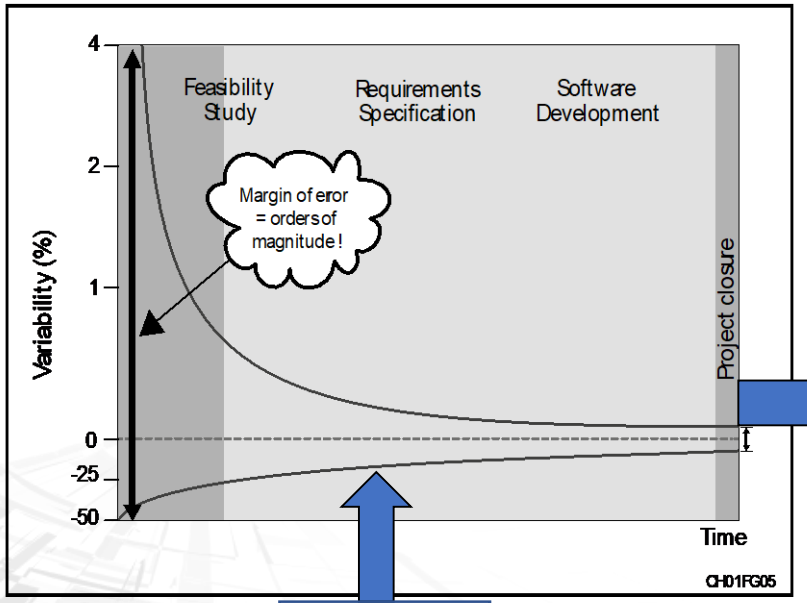
Agenda

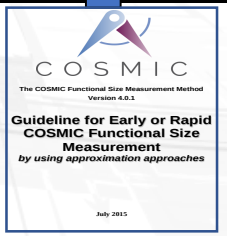
1. Software Effort Estimation & Software Size
2. COSMIC: 2nd Generation of Function Points
3. Versatility of COSMIC Function Points
4. Contributions of COSMIC to Estimation Models
5. Early & Quick COSMIC sizing at Estimation Time
6. **Summary**

Software COST Estimating: Critical knowledge for today & tomorrow

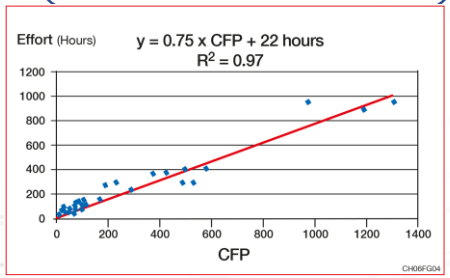
Ample industry evidence that COSMIC Function Points allow:

1. Meaningfull benchmarking
2. Early & Quick sizing
3. Estimation with very low variations (… conditions apply…)





Organization Data Repository



Thank you for your attention

?

www.cosmic-sizing.org

Alain Abran alain.abran@etsmtl.ca
Charles Symons cr.symons@btinternet.com
Christof Ebert christof.ebert@vector.com
Frank Vogelezang frank.Vogelezang@ordina.nl
Hassan Soubra: hassan.soubra@estaca.fr