

# Estimating the cost of Software for Highly Constrained Systems

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[www.software-measurement.com](http://www.software-measurement.com)

Software Measurement Services



# Software Measurement Services

- We are the largest independent consultancy in Europe dedicated to Helping clients achieve measurement driven performance improvement in software development and Maintenance
- We are an industry leader offering quantitative assessment (Via QPeP) ands qualitative assessment (Via CMM(I))
- We are the only organisation offering the SEI approved CMMI introductory course in Europe
- We invest heavily in advancing understanding in software performance measurement and improvement, and researching best practice

# What's Highly Constrained

**In addition to fulfilling their required function, these systems must also achieve predictable levels of quality and resource attributes, within tight tolerances. (PG Rule UKSMA SIG 1993)**

- Interfaces are largely or predominantly non-human.
- Time constraints heavily influence the design.
- The system must cope with significant concurrency in the problem domain.
- A high volume of message transfer between system components

# Which Systems are Highly Constrained

The following application domains are considered to display these characteristics.

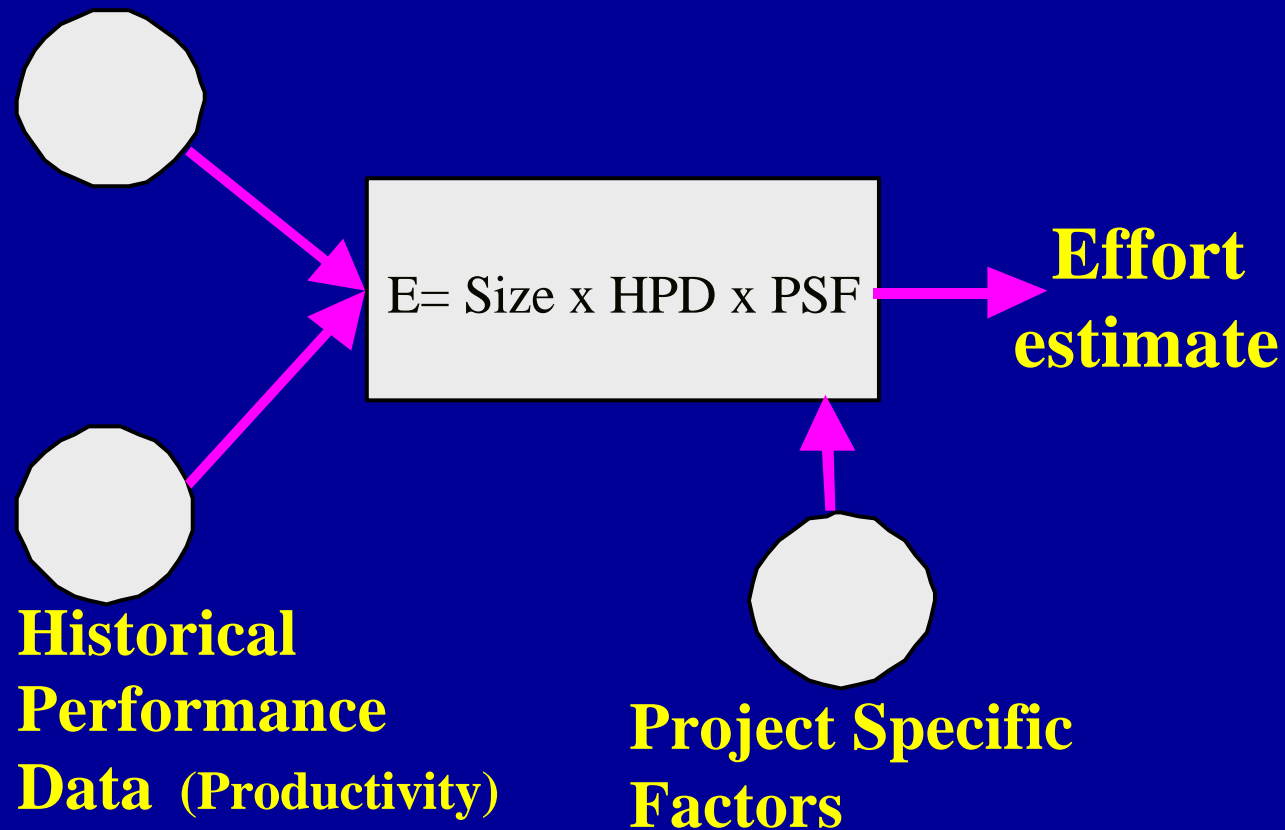
- Embedded systems
- Telecommunications
- Systems or System-integration Software
- Command & Control Systems
- Electronic Funds Transfer and Point of Sale Systems

# Estimation

- Estimating is not complicated
- It is common sense and we all do it
- In order to have Confidence in the estimate You Need:
  - Reliable well understood data
  - A repeatable process...
  - ...plus history of previous projects...  
...in, Work-Hours per Functional Size Unit
  - Use range estimates
  - Understand software project behaviour
  - Use two techniques

# Functional Size Based Estimation

## Size parameter in Function Points or COSMIC



# We need a Size measure

Lines of code – do not travel

- 1000 lines of Ada Does not equal 1000 lines of C

Function Points: are a useful size measure

- for DP/MIS, but not for most highly constrained

A new functional size measure:

- COSMIC (COmmon Software Measurement International Consortium)
- COSMIC was designed for more complex software  
– also works well for traditional software(DP/MIS)

# COSMIC - AIMS

Functional sizing measure

Across wide range of domains

World wide acceptance

Early in software item's life-cycle

Compatible with ISO 14143

Best principles of current methods

# Concepts

Layered View of Software

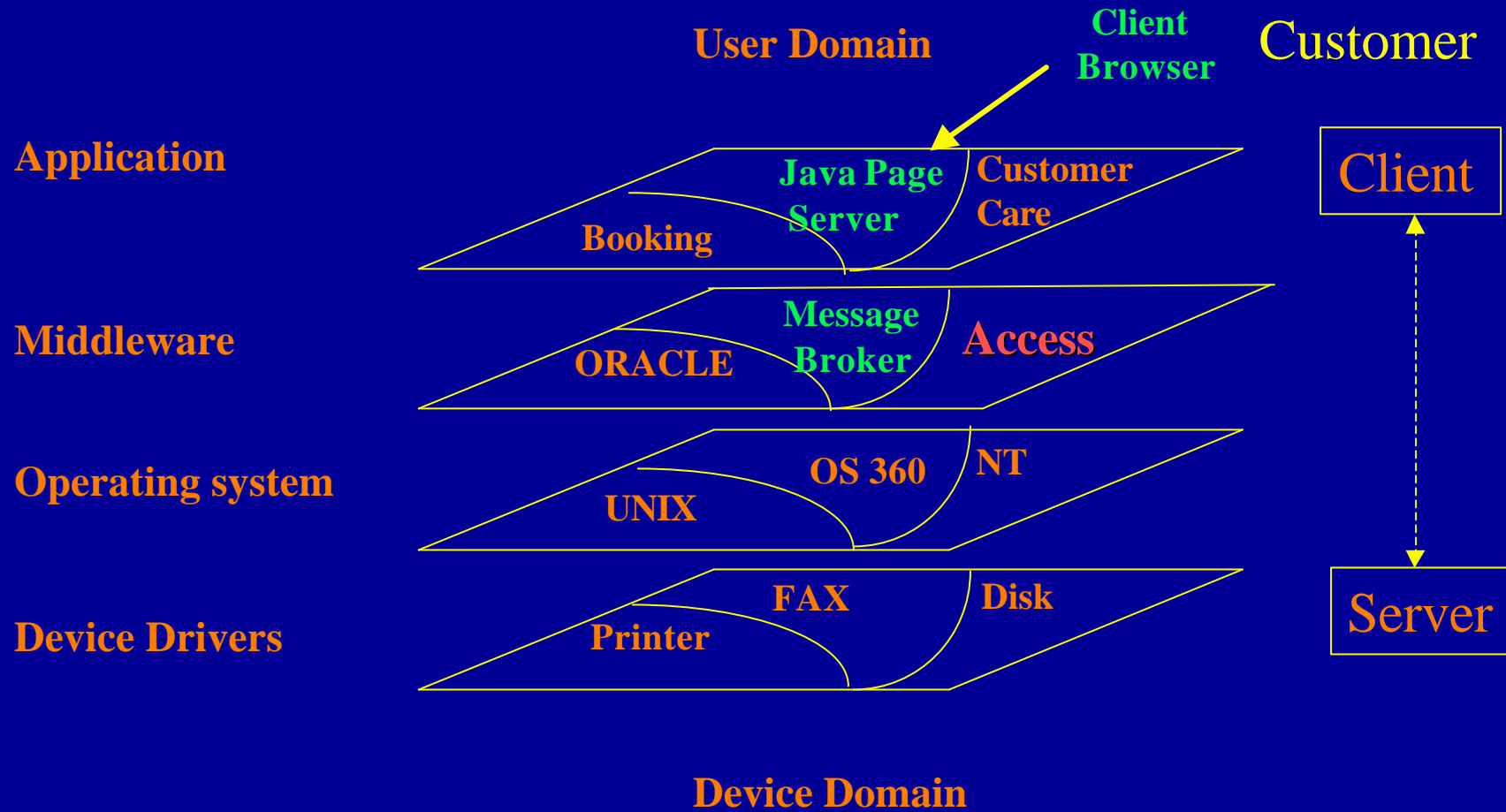
General model of software item

Base functional component types

Differing size needs – Developers - Users

Simple Unit of Size

# Layers of Software Allocation of Requirements



# COSMIC Approach

Measure size of software in the layers

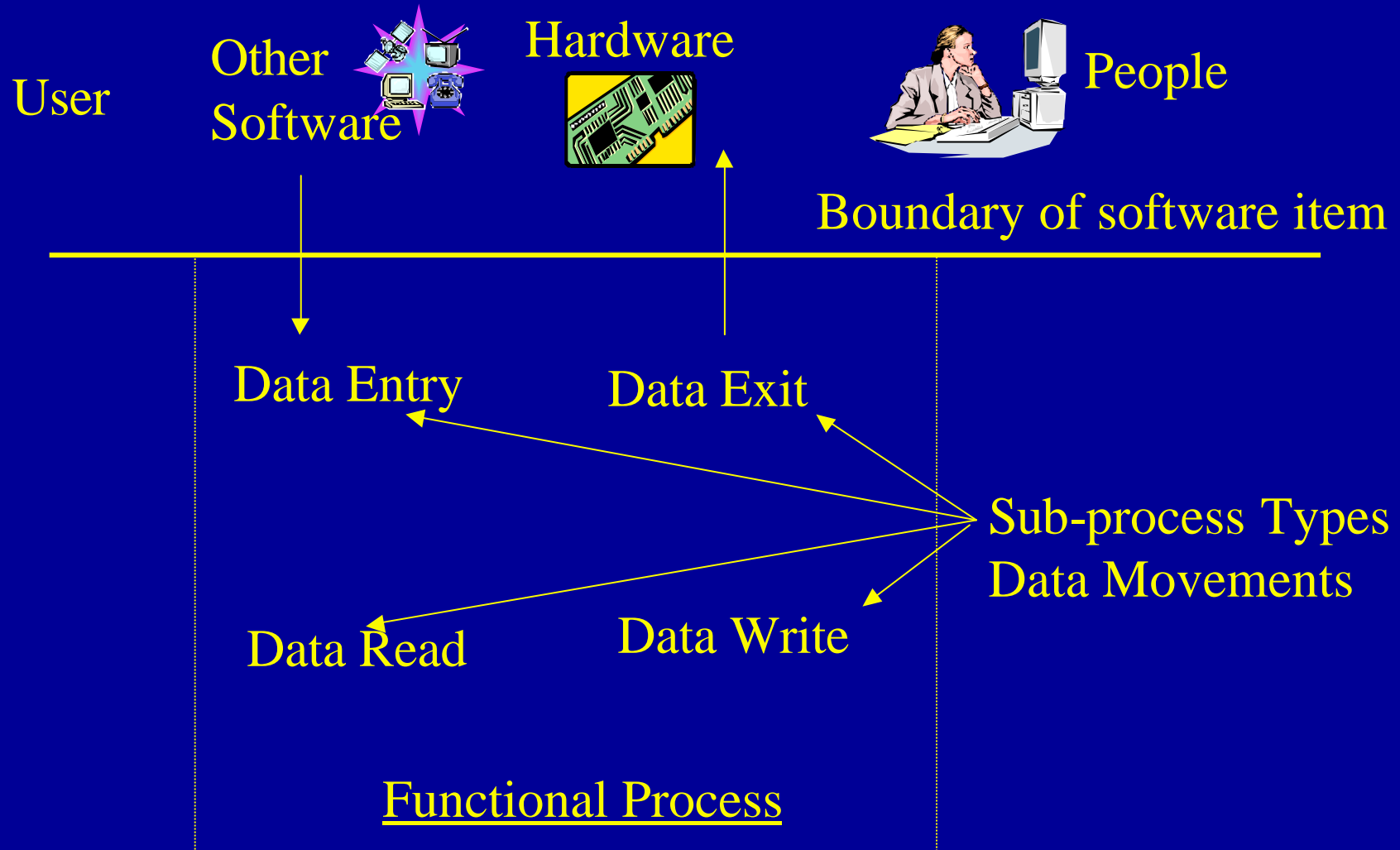
Accounts for Functional User Requirements

Accounts for performance Requirements

No need for adjustment factors

- Claimed to be subjective
- Only allow +\_ 35% - insufficient

# General Model of a Software Item

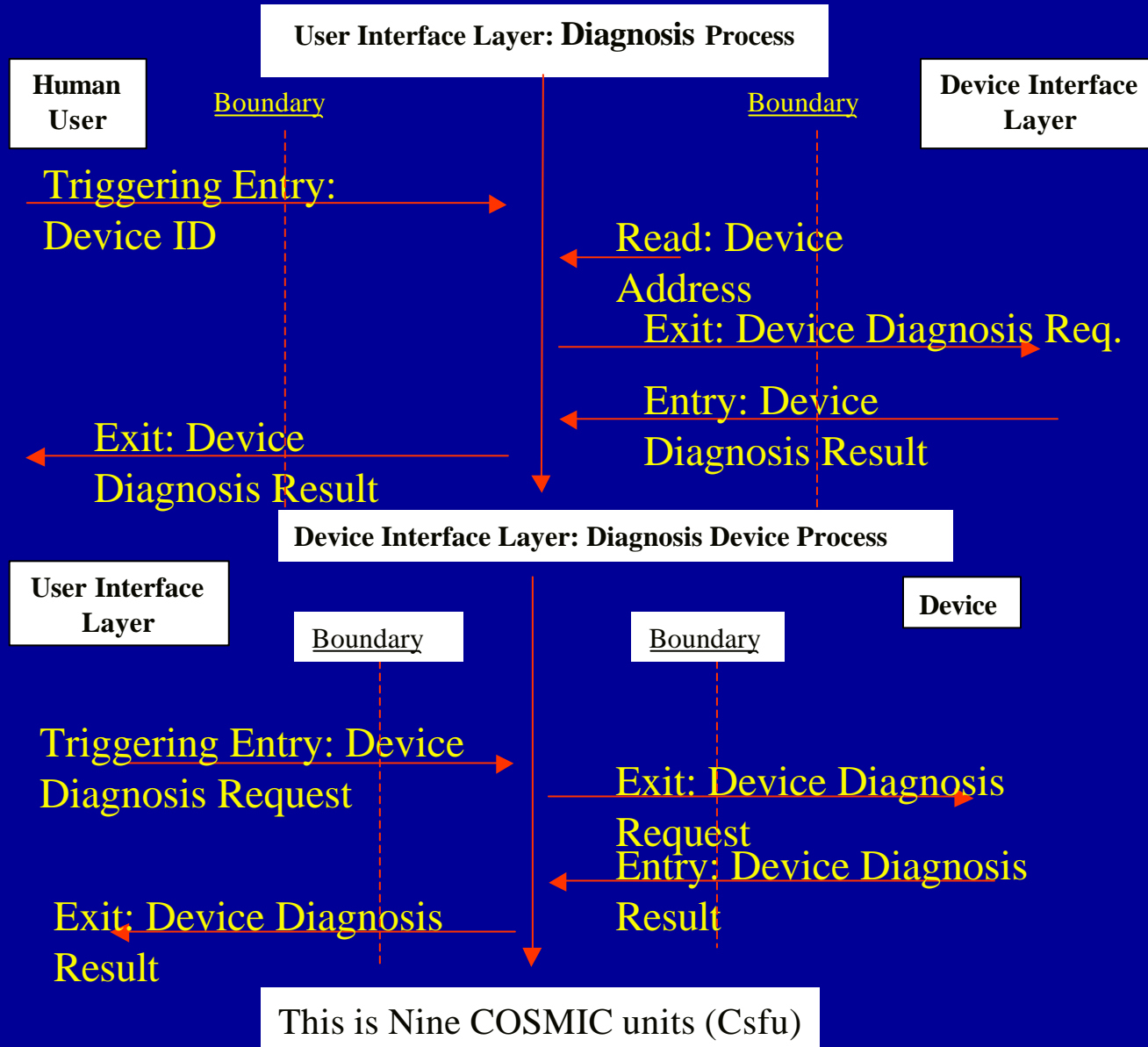


# A Cosmic Example

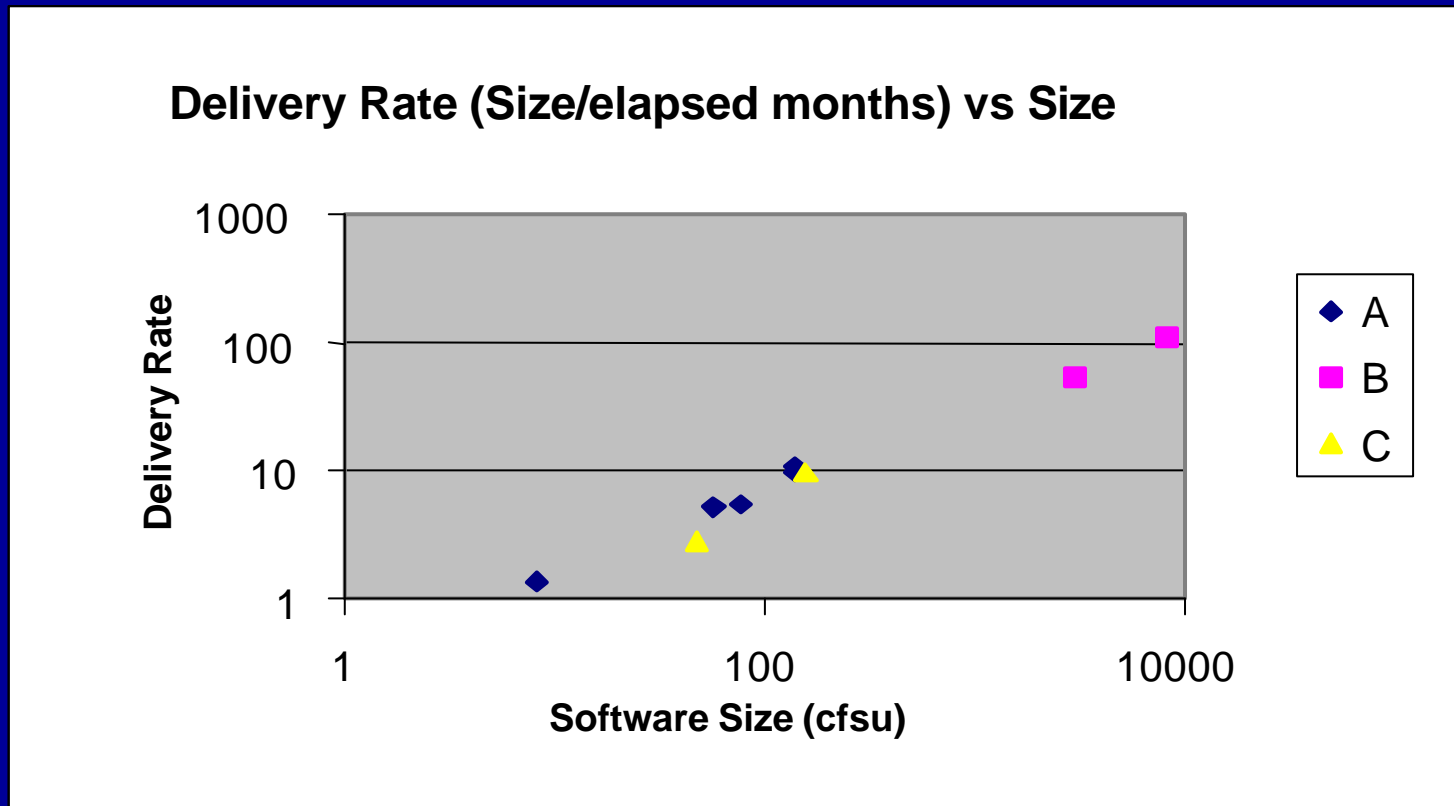
A specification of a functional Process

*Regardless of the state of the system the user should be able to do something to an icon of a failed device that starts the diagnosis process (Planning eXtreme Programming – Kent Beck)*

# COSMIC Example

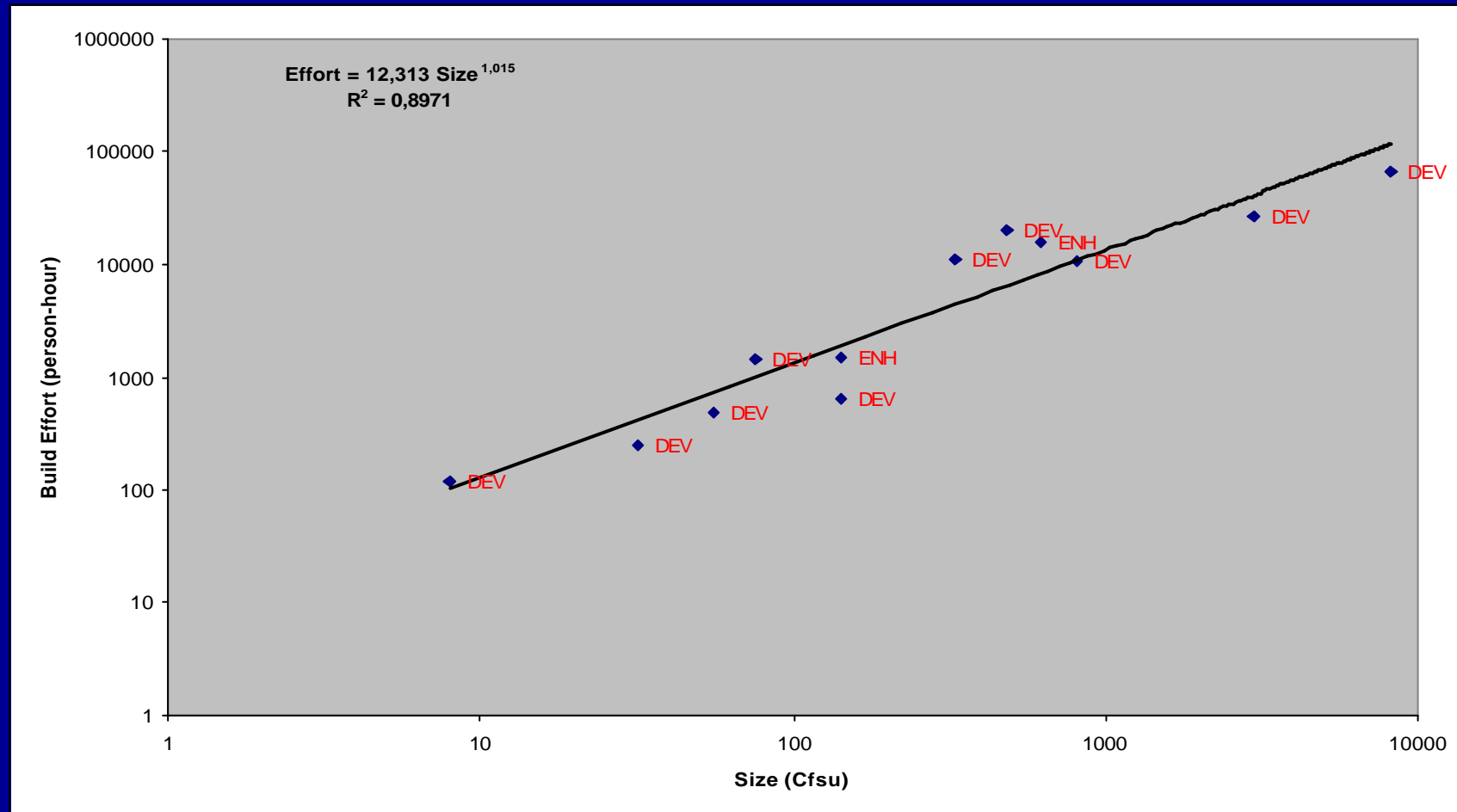


## Delivery Rate v Size: Some European Data



**Again, surprising consistency, considering the variety of technologies, size, etc.**

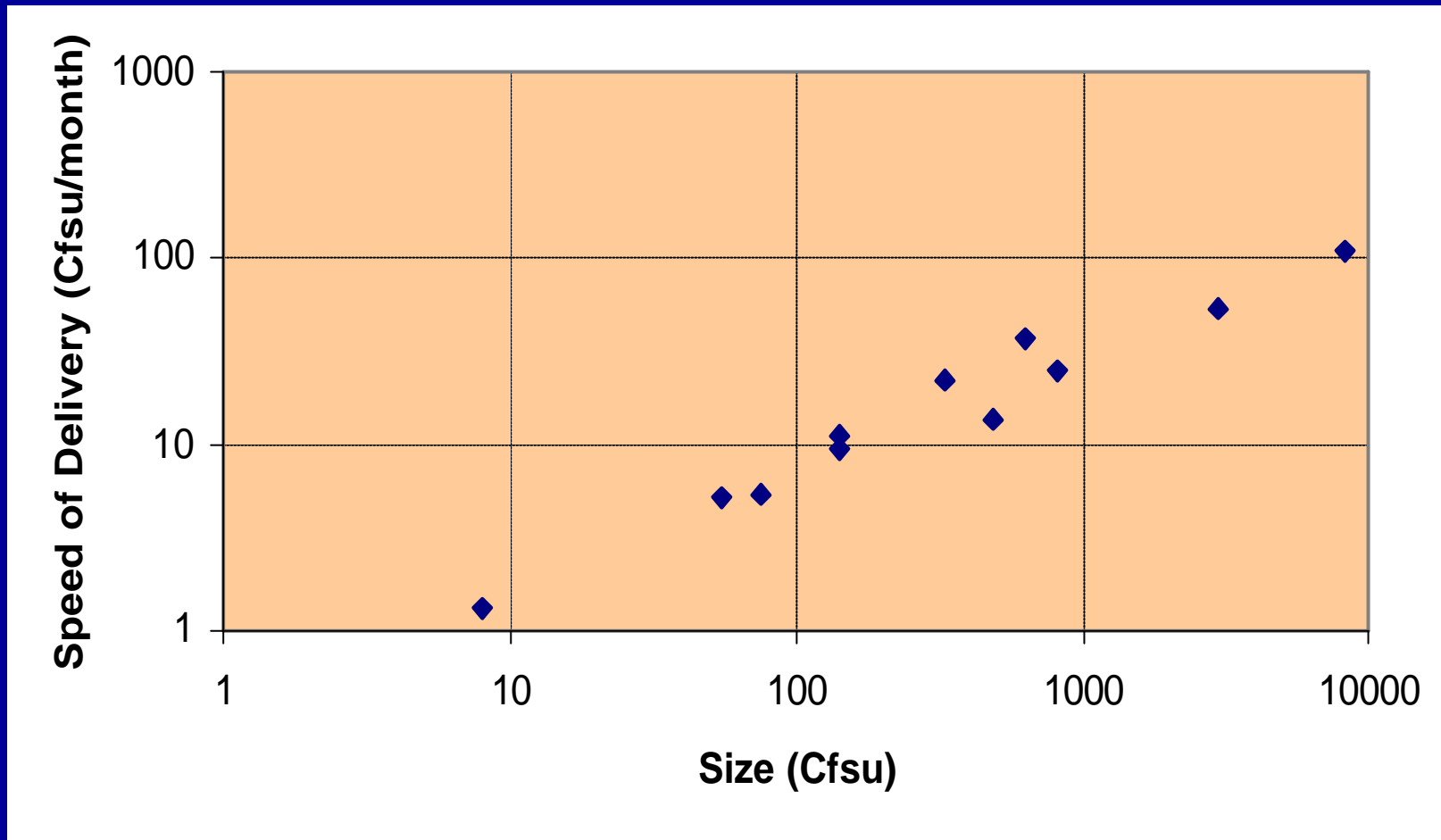
# Field Trial results for Build phase of real-time software projects (effort v size)



10 development, 2 enhancement projects from 5 companies; multiple platforms

Build effort = 12.313 x (Size)<sup>1.015</sup>. Coefficient of regression R<sup>2</sup> is 0.897

# Field trial results\*: Speed of Delivery v Size

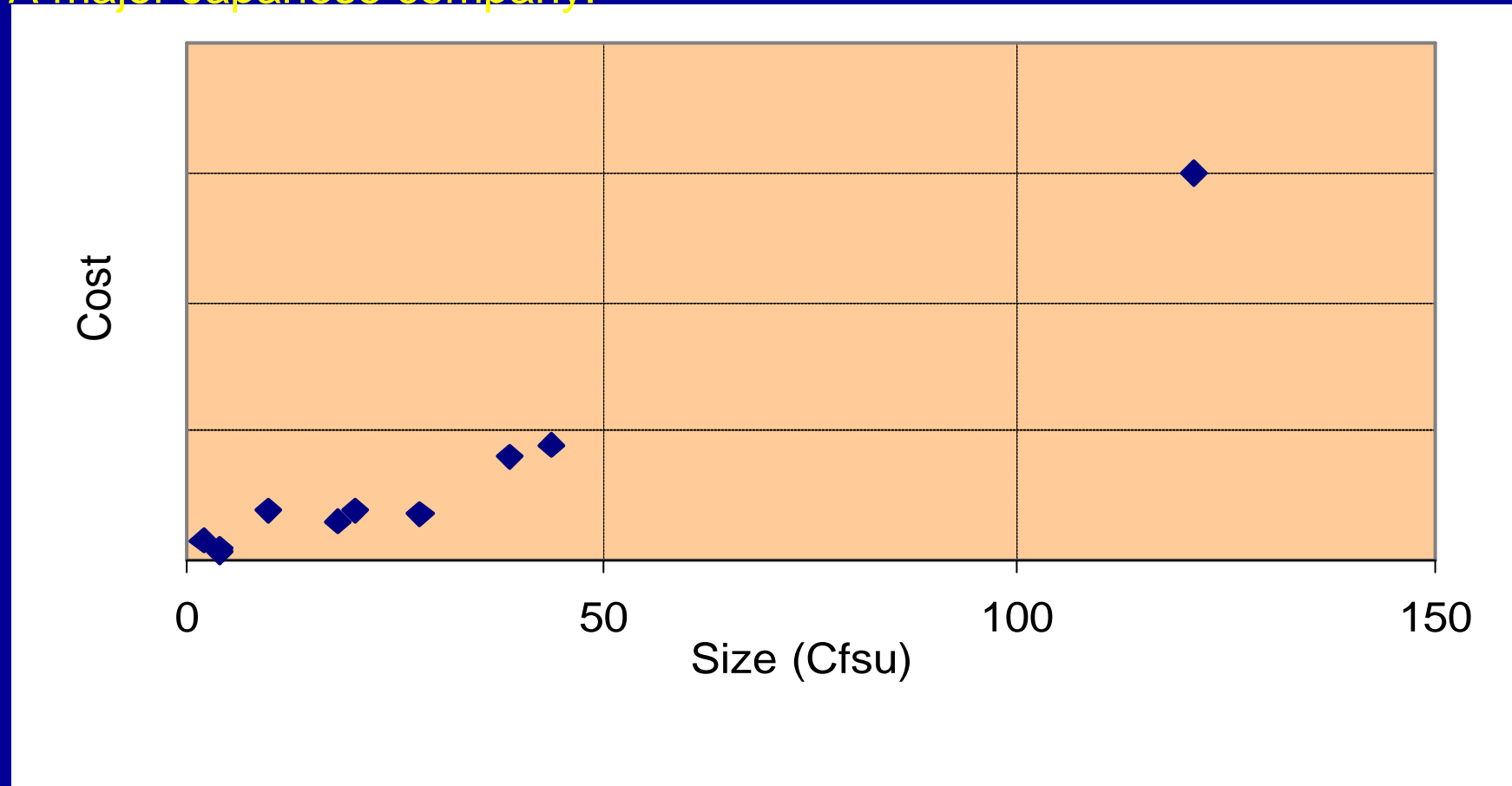


$$\text{Speed (Cfsu/elapsed month)} = 0.243 \times \text{Size}^{0.672}$$

\* Real-time projects only, from three organisations (avionics, mixed defence, telecoms)

# Telecom companies are starting to acknowledge good results

A major Japanese company:



A manager in a major European company: *'I was astonished how well sizes correlate with effort'*

# An Estimation Case Study

A simple embedded System

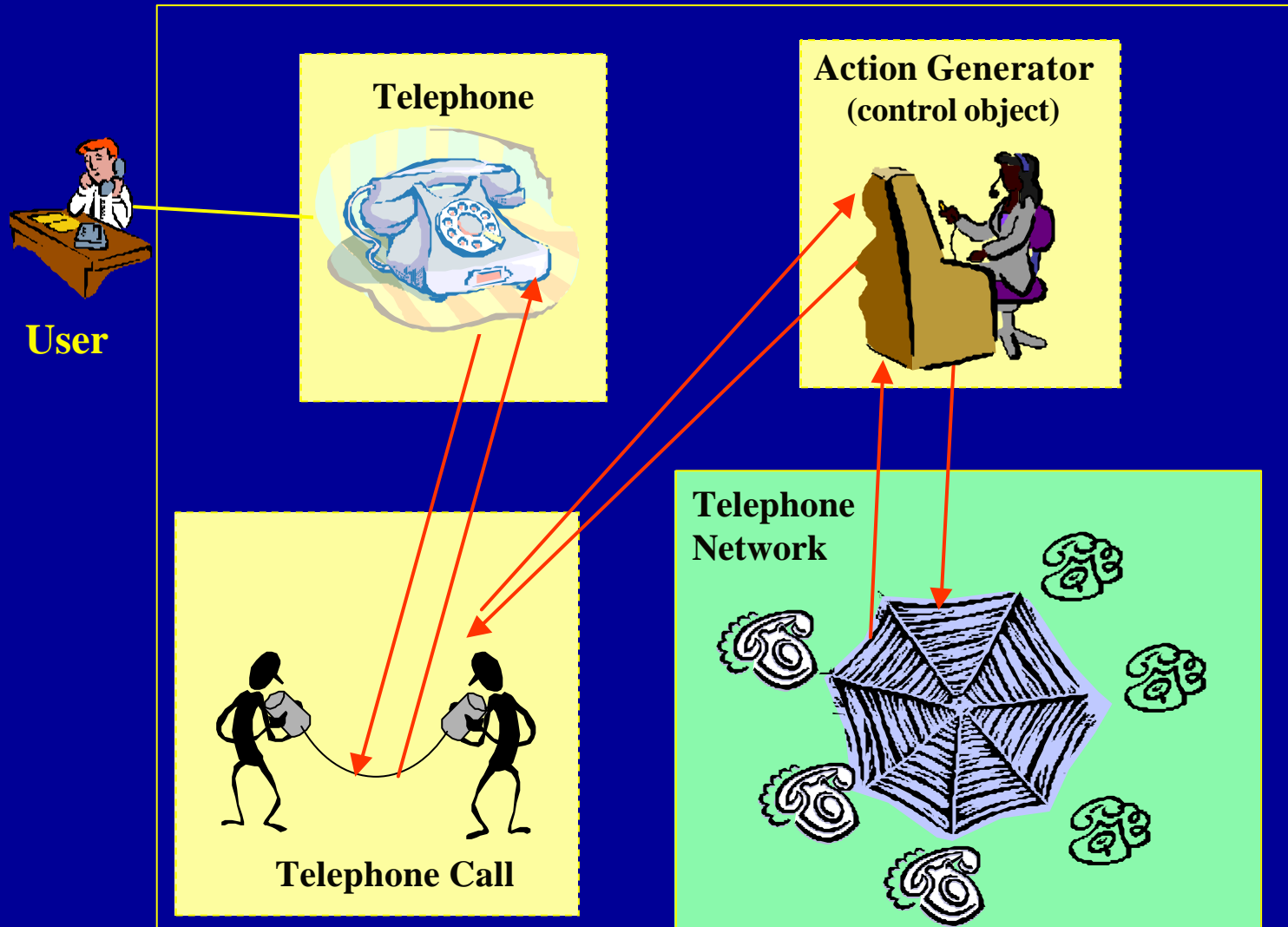
## **The Toy Telephone**

A quite sophisticated toy as it has a software Element and indeed a network capability.

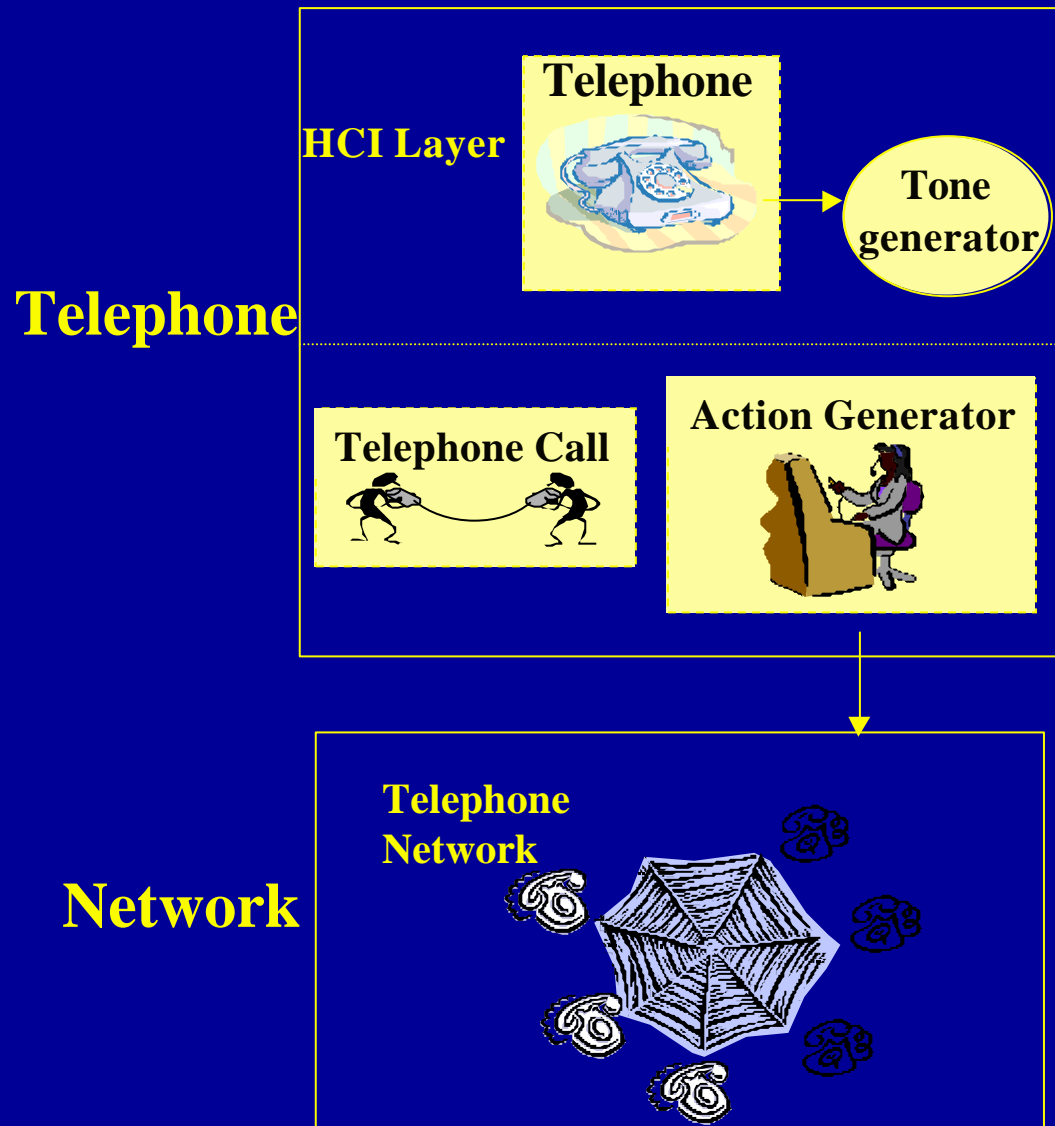
I am only going to estimate one component  
The telephone itself

The case study is published in: JSP & JSD the Jackson Approach to Software Development, IEEE Computer Society Press 1989

# The Toy Telephone



## Architecture of the Toy Telephone

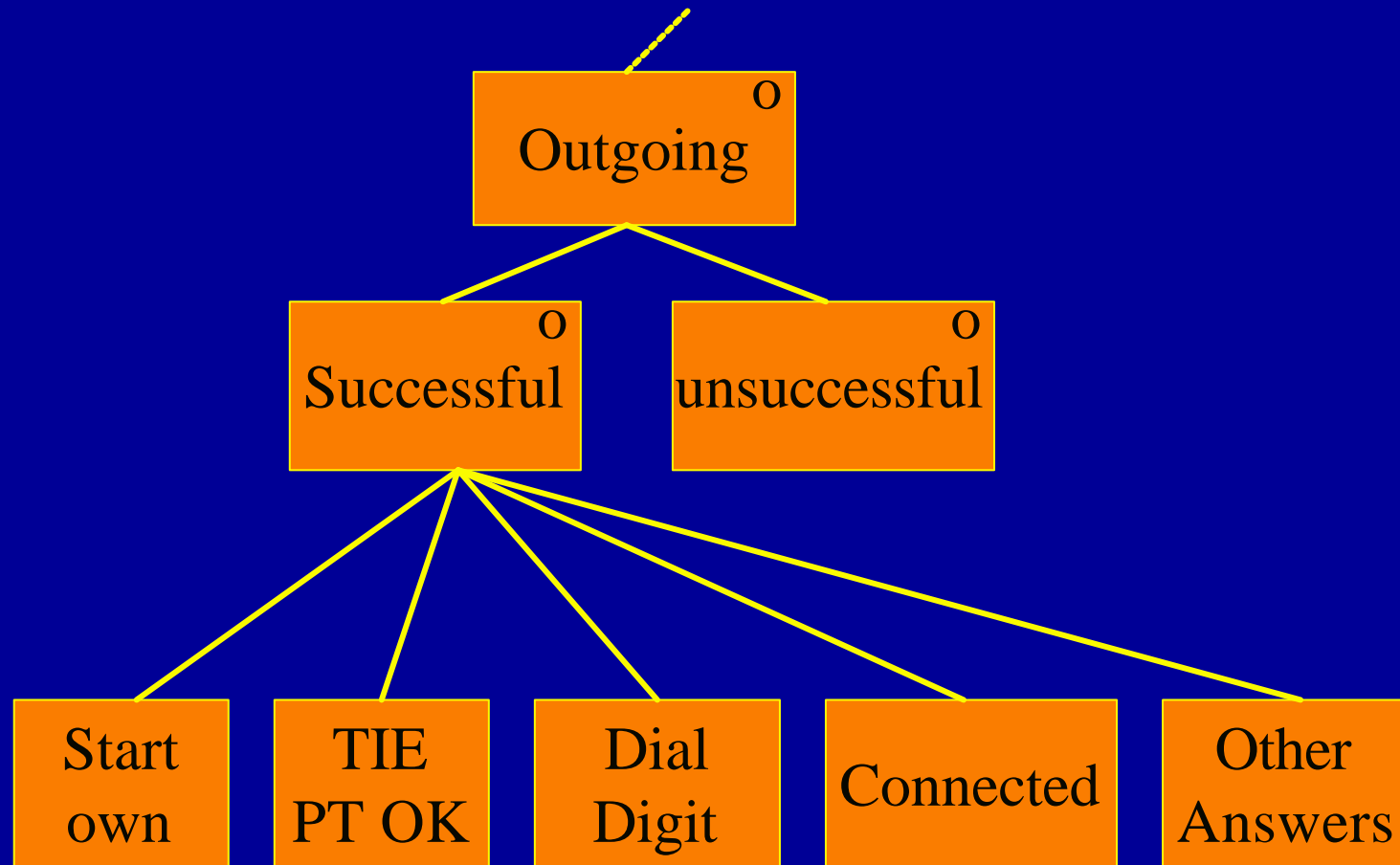


### Toy Telephone

Consists of two subsystems

1. The telephone
  1. Telephone
  2. Telephone Call
  3. Action Generator
2. The network

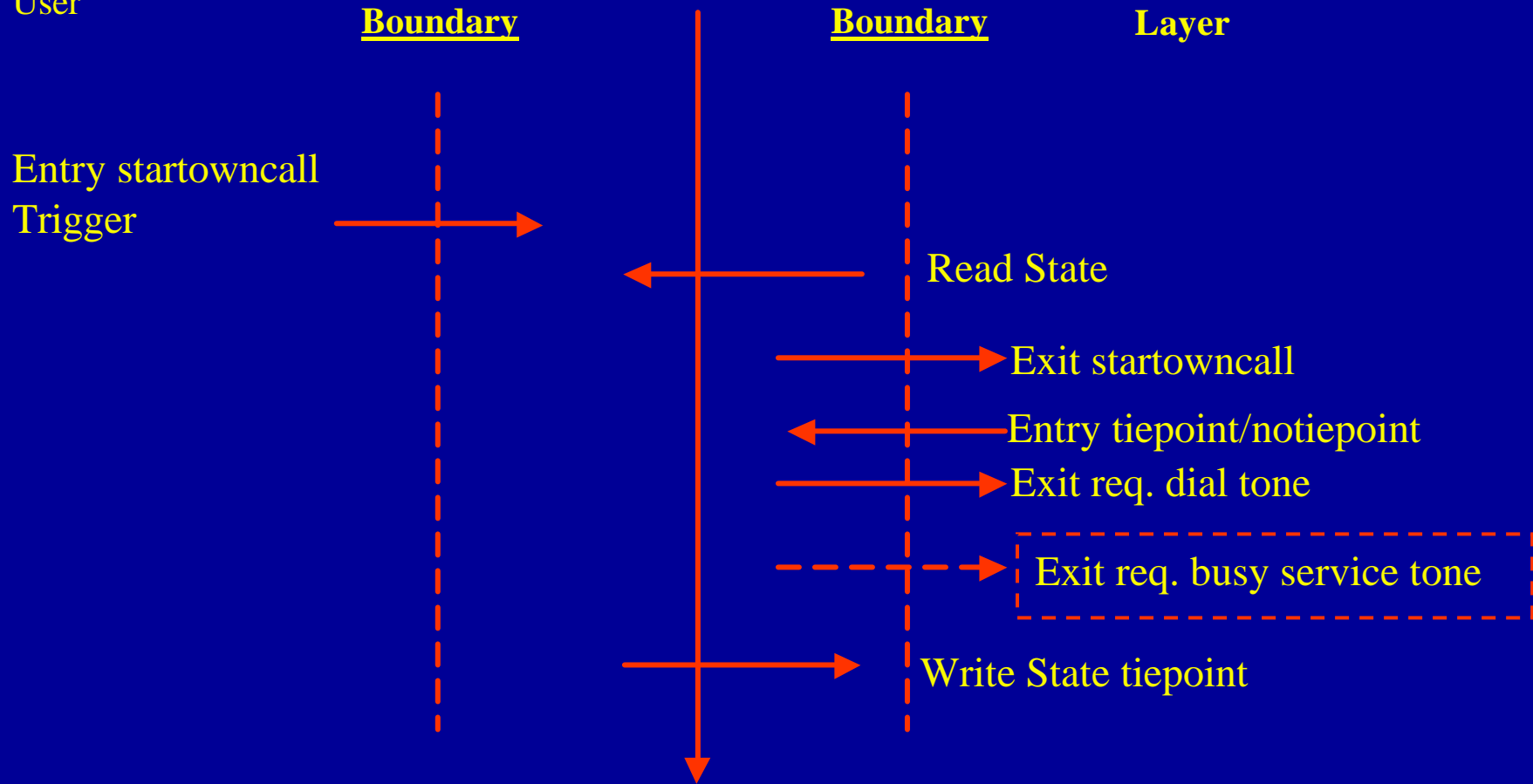
# Telephone Action Diagram (fragment)



# The STARTOWNCALL Functional Process Of the Telephone Object

Human  
User

Utility  
Layer



**This is 7 Csfu's the complete Telephone Component has 67 Csfu's**

# The Estimate

We have a measure of the size – 67 Csfu's  
We will use industry available data from the  
COSMIC field Trials

Field Trial data shows:

Median is:                    0.0371 csfu/hr - 4.5 per SM

1st Quartile is            0.0339 -                    4.1

3rd Quartile is            0.0483 -                    5.8

But Field trial is mostly safety critical software

Toy telephone not safety critical

# Try a different source of data

International Software Benchmarking Group (ISBSG)

Has twelve projects but some are from telecomms (6)

Taking telecomm only we have

	csfu/sm
Median	9.46
Lower Quartile	4.18
Upper Quartile	19.7

This is likely to fit our project better though we have a wider spread

# The Estimate

	<b>Field Trial</b>	<b>ISBSG</b>
	<b>staff hours</b>	<b>staff hours</b>
<b>Least :</b>	<b>1385</b>	<b>408</b>
<b>expected:</b>	<b>1806</b>	<b>850</b>
<b>greatest:</b>	<b>1974</b>	<b>1921</b>

**As our basic estimate.**

# Phase Estimates

The data also shows that:

	FT	ISBSG
Specification consumes:	22%	14%
Construction consumes:	42%	62%
Testing Consumes:	36%	24%

Using ISBSG breakdown as more likely  
we can predict likely phase effort

Specification:	122 staff hours
Construction:	528 staff hours
Testing:	200 staff hours

# Estimates of Duration

This is a relatively small system so we assume an average team size: Of 3 at 120hrs/month

duration = effort/staff

duration = 408/3      849/3      1921/3

duration = 136hrs      283hrs      640hrs

months: = 1.1      2.4      5.3

You may of course prefer to base this on the phase effort in which case it should be more accurate once you have decided on staffing for each phase

Allocating 1 to spec 3 to build and 2 to test gives:  
3.3 months duration

# Estimate of Duration

The last slide was simplistically based on an average staffing for the project

If we assume 1 staff allocated to specification

3 staff to build

2 staff to test

Then we get:

Specification	1	month
Build	1.5	months
Test	0.8	month
Total	3.3	months

# Improving Estimation

I have used general industry data

Estimation can be greatly improved if you

Collect your own data –

effort, duration/phase and size

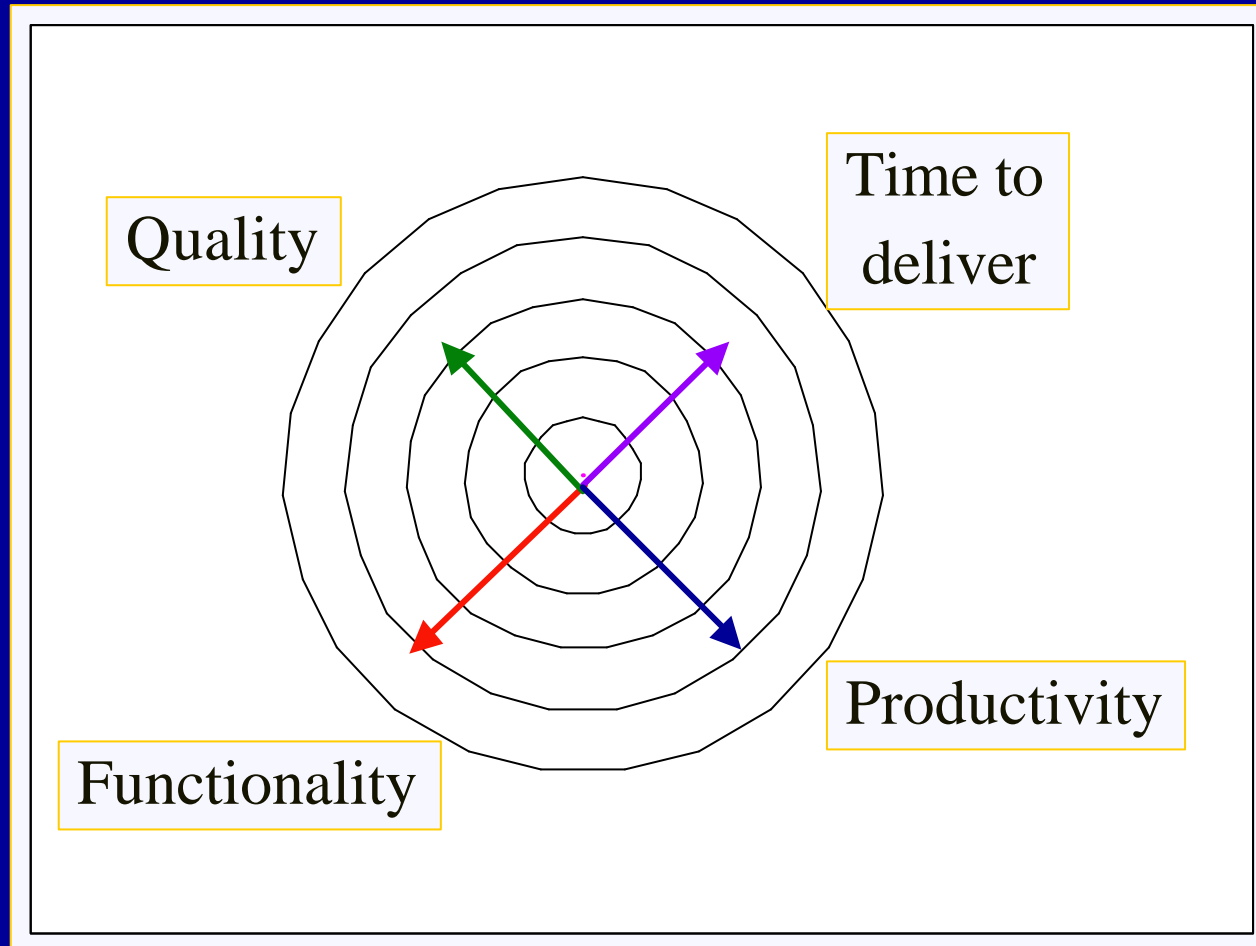
Categorise projects

Team size, language, project type

What you need is data that can be matched to the project and is reliable.

You can make good estimates with very little data if it matches your project.

# Understand Project Behaviour



**Varying any of these factors will impact the others**  
**Productivity is also affected by team size**

# Conclusion

- Functional Sizing is now available to HCS
- So are all the benefits
- COSMIC gives good correlation between size and effort
- Good Estimates Require:
  - Historical Data
  - Repeatable Processes
  - Practice

# Further Information

## **COSMIC**

**[www.lrgl.uqam.ca](http://www.lrgl.uqam.ca)**

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**[Charles\\_Symons@compuserve.com](mailto:Charles_Symons@compuserve.com) - joint PM COSMIC  
project**

## **Estimation**

**[www.isbsg.org.au](http://www.isbsg.org.au) – data CD - estimation training kit**

**[www.software-measurement.com](http://www.software-measurement.com) – several consultants  
trained in COSMIC all in estimation**