25th anniversary
annual INCOSE
international symposium
Seattle, WA
July 13 - 16, 2015

When two is good company, but more is not a crowd

Andy J Nolan, Andrew C Pickard,
Jennifer L Russell and William D Schindel


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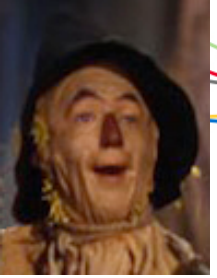
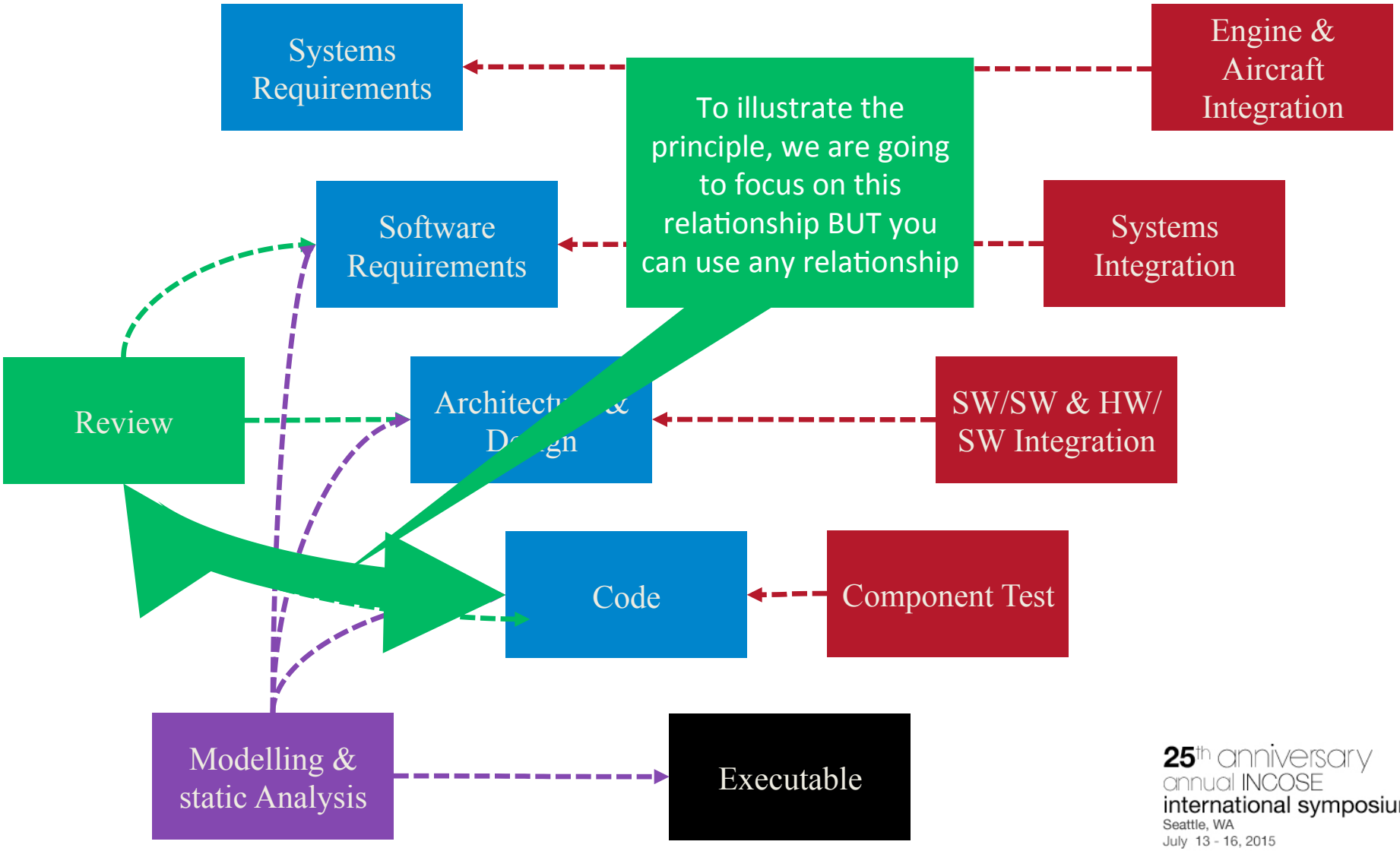
When 2 is good company…

Duo Combinations

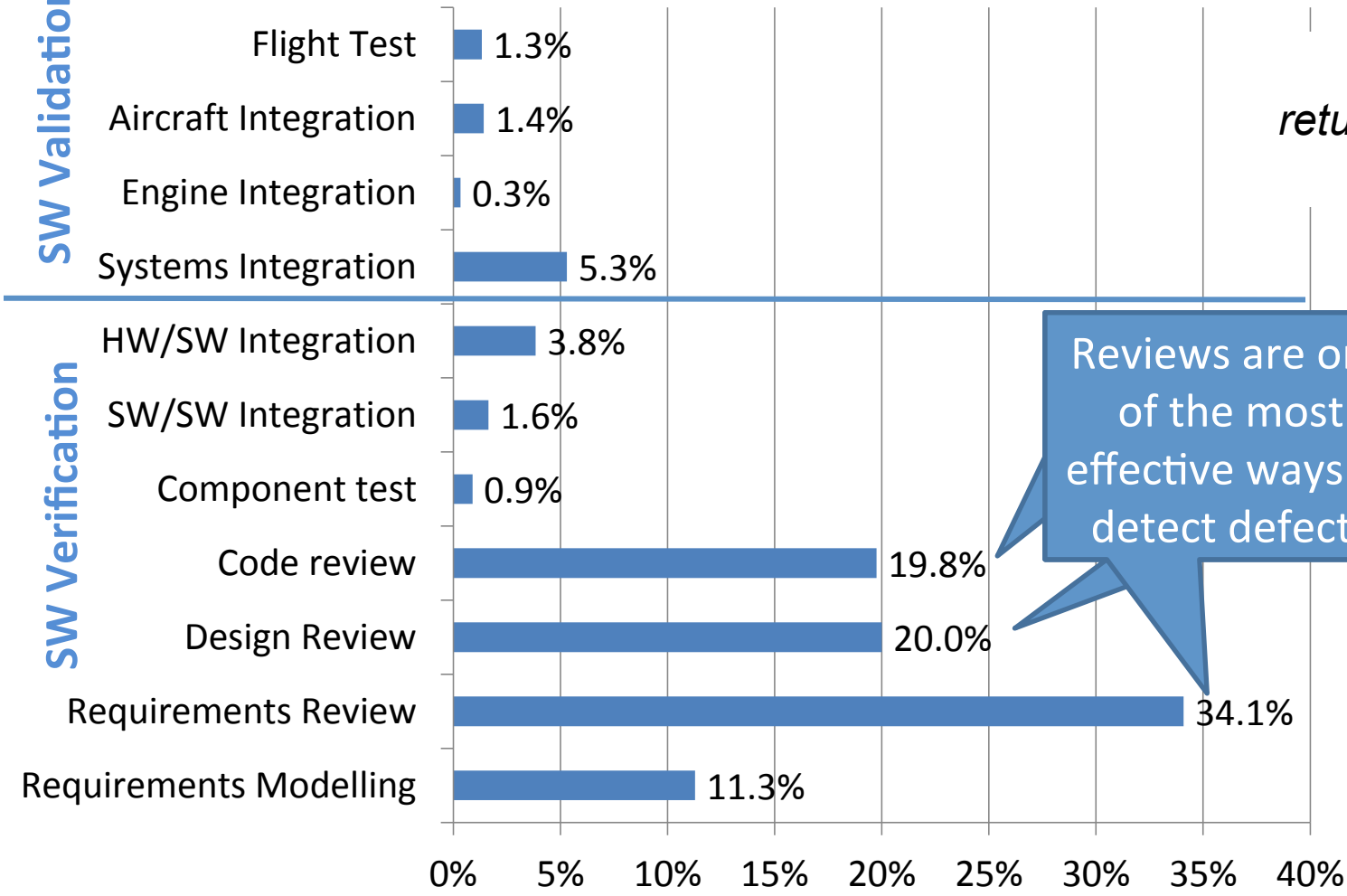
Lead Role \ Side Kick	High Performer	Low Performer
High Performer		
Low Performer		



The software development process



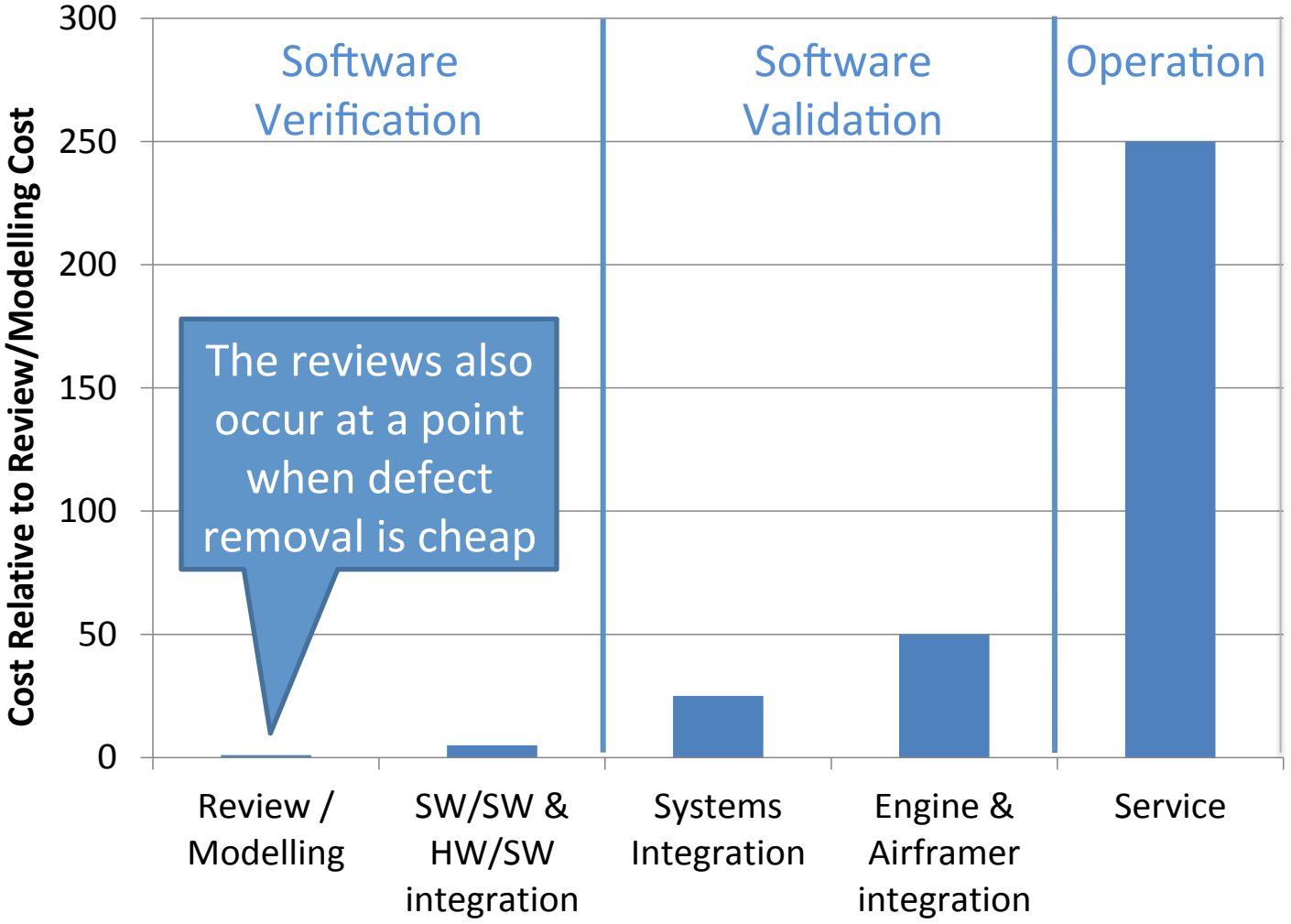
Where defects are detected

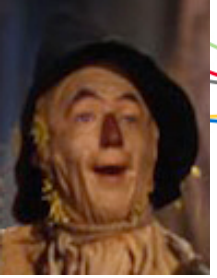


Review return on investment is 100:1!

Reviews are one of the most effective ways to detect defects

The cost of defect escapes





Effectiveness of V&V

BUT analysis on where defects escape show that it is not as effective as it could be

Where found \ Were should have been found	Requirements Modelling	Requirements Review	Design Review	Code Review	Component Test	SW/SW Integration	HW/SW Integration	System Integration	Engine Integration	Flight Test
Requirements Modelling	185									
Requirements Review	129	458								
Design Review	36	128	77							
Code Review	8	78	32	102						
Component Test	0	1	3	9	4					
SW/SW Integration	1	45	61	60	0	30				
HW/SW Integration	1	10	55	30	0	0	13			
System Integration	18	145	18	5	0	19	1	41		
Engine Integration	10	11	14	0	0	3	3	3	4	
Flight Test	1	6	16	2	0	1	1	6	3	6

The cost of defect escape!

BloombergBusiness

GM's Newest Recall Covers 52,000 SUVS Over Software Flaw

by Dan Hart
May 3, 2014 — 11:28 AM CDT

GM took a $1.3 billion charge in the quarter ended March 31 to cover recall costs.

Toyota recall costs: $2 billion

By Chris Isidore, senior writer February 4, 2010: 10:00 AM ET

NEW YORK (CNNMoney.com) -- Toyota Motor says the massive recalls of vehicles due to gas pedal problems could end up costing it $2 billion.

edmunds.com

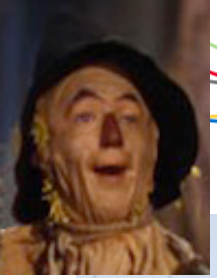
842,000 Chrysler Vehicles Recalled in Five Separate Campaigns

By Anita Lienert | Published Jul 5, 2013

Just the Facts:

- **Chrysler Group has recalled more than 842,000 vehicles in five separate campaigns to correct a variety of safety-related issues.**
- **Recall issues range from misprogrammed airbag software to faulty head restraints.**

To halve the defects escaping review.



THE SCIENCE

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What do you like most?

Do you enjoy making things?

OR

Do you enjoy critiquing things?

Author Effectiveness

Number of defects introduced per X where X = code, design, requirement etc.

Measure after the fact and trace each defect to its source. Look at all defects e.g. review, test, modelling, analysis…

Author Effectiveness

Author Effectiveness	
Defects introduced per 1000 lines	
A	0.5
B	1.0
C	3.0
D	4.0
E	10.0
F	18.0

We observed a 10 fold difference in ability

Reviewer Effectiveness

% of defects detected vs defects that escaped

Where found \ Were should have been found	Requirements Modelling	Requirements Review	Design Review	Code Review	Component Test	SW/SW Integration	HW/SW Integration	System Integration	Engine Integration	Flight Test
Requirements Modelling	185									
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System Integration	18	145	18	5	0	19	1	41		
Engine Integration	10	11	14	0	0	3	3	3	4	
Flight Test	1	6	16	2	0	1	1	6	3	6

Reviewer Effectiveness

Reviewer effectiveness defect detection rate					
C	B	A	E	D	F
94%	80%	75%	50%	45%	30%

In this case we had a 3-fold difference in ability. A second study showed a 10-fold difference

Modelling Pairs

Most effective

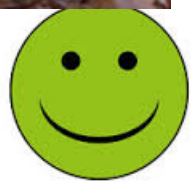
Author Effectiveness			Reviewer effectiveness defect detection rate					
			C	B	A	E	D	F
			94%	80%	75%	50%	45%	30%
Defects introduced per 1000 lines	A	0.5						
	B	1.0						
	C	3.0						
	D	4.0						
	E	10.0						
	F	18.0						

Modelling Pairs

defect escape =
defects introduced –
defects detected

Author Effectiveness Defects introduced per 1000 lines			Reviewer effectiveness defect detection rate					
			C	B	A	E	D	F
			94%	80%	75%	50%	45%	30%
	A	0.5	0.0	0.1		0.3	0.3	0.4
	B	1.0	0.1		0.3	0.5	0.6	0.7
	C	3.0		0.6	0.8	1.5	1.7	2.1
	D	4.0	0.2	0.8	1.0	2.0		2.8
	E	10.0	0.6	2.0	2.5		5.5	7.0
	F	18.0	1.1	3.6	4.5	9.0	9.9	

Modelling Pairs



<1 defect / 1000 lines

1-2 defect / 1000 lines

>2 defects / 1000 lines

Author Effectiveness		Defects introduced per 1000 lines	Reviewer effectiveness defect detection rate					
			C	B	A	E	D	F
			94%	80%	75%	50%	45%	30%
	A	0.5						
	B	1.0						
	C	3.0						
	D	4.0						
	E	10.0						
	F	18.0						

Don’t leave teams to chance. Always at least one strong person

Modelling Pairs

When two is good company, but more is not necessarily a crowd

Author Effectiveness		Defects introduced per 1000 lines
	A	0.5
	B	1.0
	C	3.0
	D	4.0
	E	10.0
	F	18.0

Reviewer effectiveness defect detection rate					
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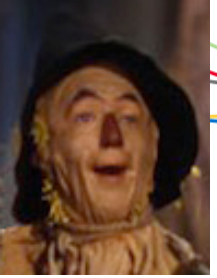
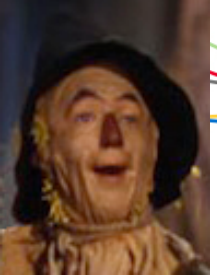
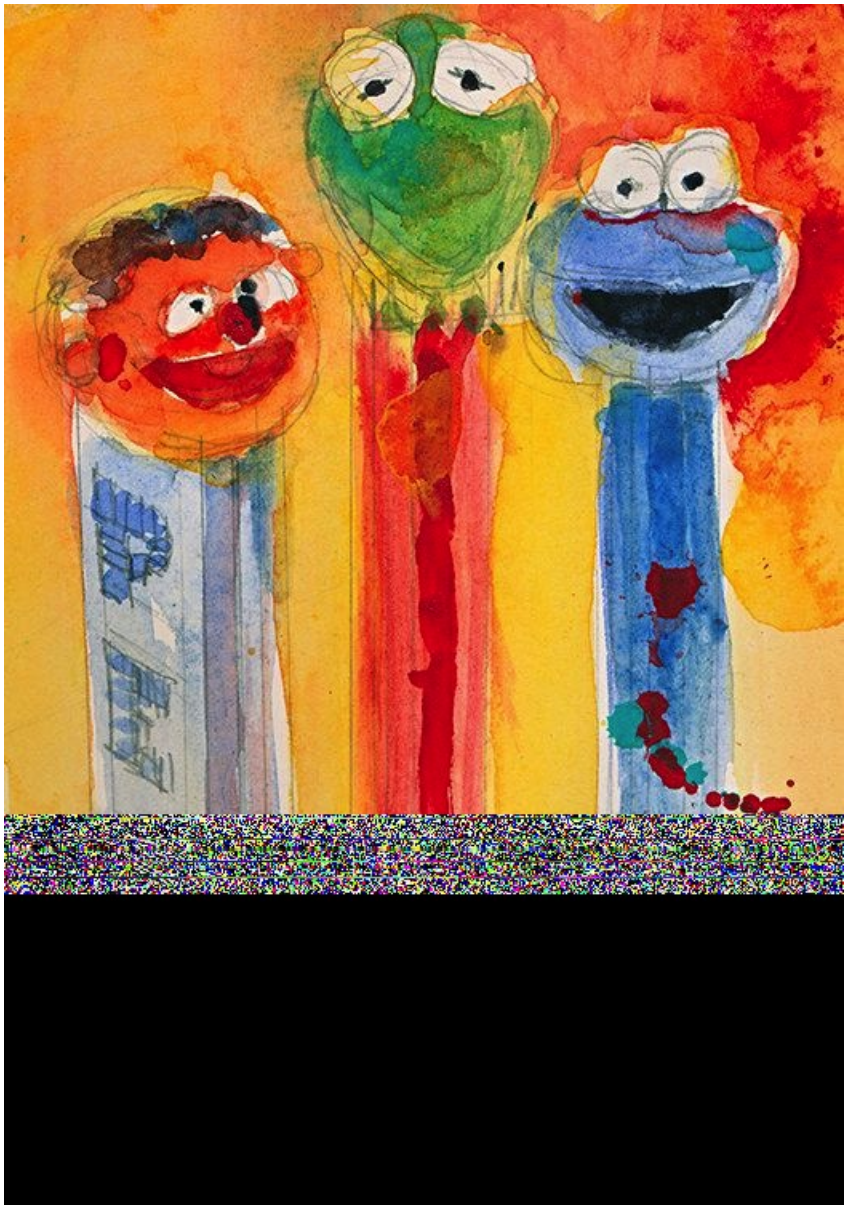


The art and science of capability

Not always possible, appropriate or legal to measure capability.
We need another way to understand capability





THE ART

Understand Effectiveness

	Author Effectiveness rank	Reviewer Effectiveness rank
Person 1	1	2 (*tie rating)
Person 2	2	
Person 3	3	
Person 4	4	
Person 5	5	2 (*tie rating)
Person 6	6	
Person 7		1
Person 8		4
Person 9		5
Person 10		6

Good reviewers are not necessarily good authors (and vice versa)

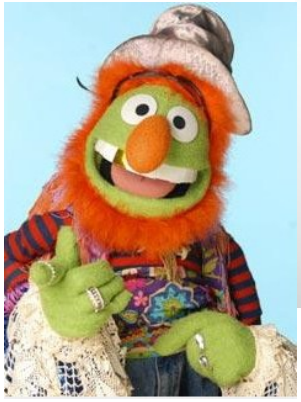
Despite detailed checklists and process, review effectiveness didn't improve

Eliminating Controlled Factors

- Potential factors affecting review effectiveness
  - Training
  - Experience
  - Processes
  - Aptitude/attitude

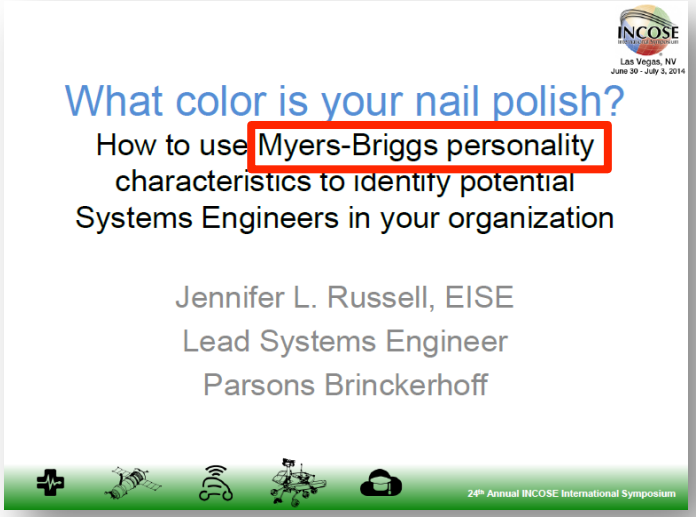
Anecdotal observations…

Authors



Reviewers

To characterize the team



MBTI Characteristics

- Energy
  - Introversion
  - Extroversion
- Decisions
  - Thinking
  - Feeling
- Information
  - Sensing
  - Intuitive
- Structure
  - Judging
  - Perceiving

Innate preferences

MBTI – *S* and *N* Information Processing

Sensing

Discrete, independent parts make a whole

- Step-by-step is best
- Logical and analytical
- Looks for details

Intuitive

- Sees how parts are connected
- Seems to know the next step
- Applies new concepts with little direction

Needs to see the whole picture

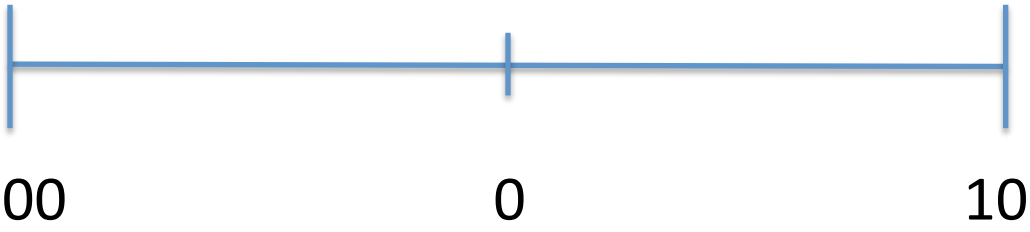
Reviewer characteristics

xSxx

Author characteristics

xNxx

MBTI – *J* and *P* External Structure



Judging	**Perceiving**
Clear right and wrong	Creative solution generators
Hierarchical	Flexible
Organized	Open Ended
Prefers fixed (non-flexible) structure	Prefers adjustable structure

Reviewer characteristics

xxxJ

Author characteristics

xxxP

MBTI Assessment

Consider attitude or aptitude

Observational Analysis

		MBTI Type (estimated)
Authors	Person 1	ISTJ
	Person 2	ENxP
	Person 3	xNTP
	Person 4	xxFP
	Person 5	ISTJ
	Person 6	xNxP
Reviewers	Person 7	ISTJ
	Person 1	ISTJ
	Person 5	ISTJ
	Person 8	ISFJ
	Person 9	ISFJ
	Person 10	ENTP

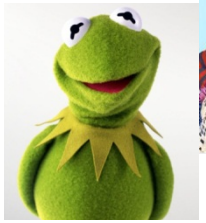
x = not enough information to estimate this

MBTI Assessment

Consider attitude or aptitude

Observational Analysis

		MBTI Type (estimated)
Authors	Person 1	ISTJ
	Person 2	ENxP
	Person 3	xNTP
	Person 4	xxFP
	Person 5	ISTJ
	Person 6	xNxP
Reviewers	Person 7	ISTJ
	Person 1	ISTJ
	Person 5	ISTJ
	Person 8	ISFJ
	Person 9	ISFJ
	Person 10	ENTP



x = not enough information to estimate this

Pair for strengths

When two is good company,

…add more as needed

more is not necessarily a crowd

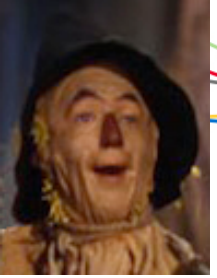
Author Effectiveness: Defects introduced per 1000 lines			Reviewer effectiveness: defect detection rate					
			C	B	A	E	D	F
			94%	80%	75%	50%	45%	30%
	A	0.5	0.0	0.1		0.3	0.3	0.4
	B	1.0	0.1		0.3	0.5	0.6	0.7
	C	3.0		0.6	0.8	1.5	1.7	2.1
	D	4.0	0.2	0.8	1.0	2.0		2.8
	E	10.0	0.6	2.0	2.5		5.5	7.0
	F	18.0	1.1	3.6	4.5	9.0	9.9	

Reviewer

S and J

Author

N and P



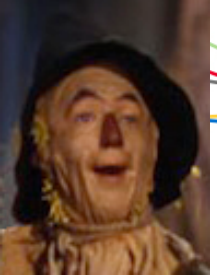
Summary

- Authors' errors and reviewer detection can be measured and vary
- Error escapes can be minimized by selectively pairing authors and reviewers
- Selective pairing can be done without direct measurement

Reviewer characteristics **Author characteristics**

$_{x}S_{x}J$ $_{x}N_{x}P$

- Multiple reviews can further reduce error escapes
- Pattern: Measure the capabilities of team members in terms of rate of error introduction and detection. Never pair a developer who is prone to introducing errors with a reviewer who is poor at detecting errors



THE PATTERNS

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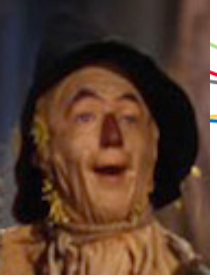
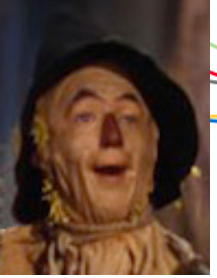


Patterns in the Review Process

- "Pattern" - A reusable solution to a commonly occurring problem
- We used two pattern representations:
  1. Prose Template Patterns:
     - Based on work of C. Alexander (Alexander 1977)
     - Template describes Problem Statement, Forces or Tensions, and Context, in prose form
  2. Model-Based S*Patterns:
     - Based on S*Patterns, described by INCOSE MBSE Initiative Patterns Challenge Team (Schindel, 2005)
     - Patterns described as configurable MBSE models



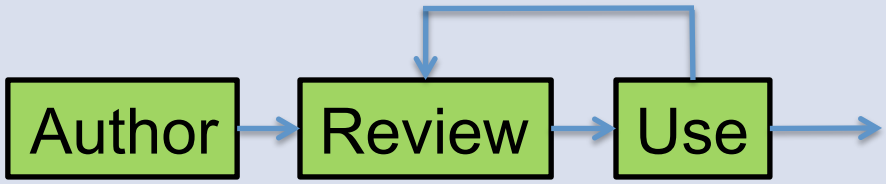
5 Review and 3 Approval Patterns

1. Who Reviews What?

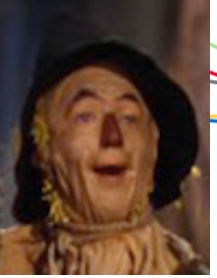
2. Effective Reviews Address Error Escapes

			Reviewer effectiveness defect detection rate					
			C	B	A	E	D	F
			94%	80%	75%	50%	45%	30%
Author Effectiveness	A	0.5	0.0	0.1		0.3	0.3	0.4
	B	1.0	0.1		0.3	0.5	0.6	0.7
	C	3.0		0.6	0.8	1.5	1.7	2.1
Defects introduced per 1000 lines	D	4.0	0.2	0.8	1.0	2.0		2.8
	E	10.0	0.6	2.0	2.5		5.5	7.0
	F	18.0	1.1	3.6	4.5	9.0	9.9	

3. Train Your Reviewers



4. Train Your Authors



5 Review and 3 Approval Patterns

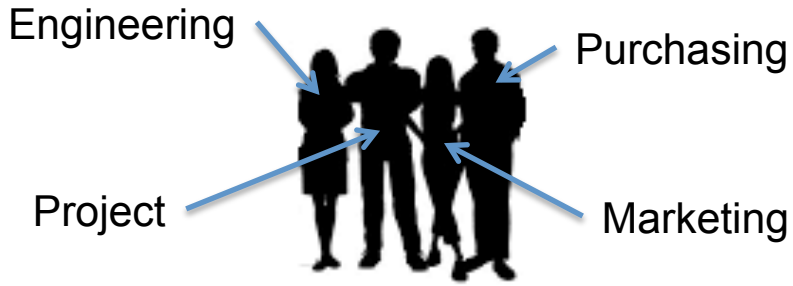
5. Danger! Difficult Function!

			Reviewer effectiveness defect detection rate					
			C	B	A	E	D	F
			94%	88%	75%	50%	45%	30%
Author Effectiveness	A	0.5	0.0	0.1		0.3	0.3	0.4
	B	1.0	0.1		0.3	0.5	0.6	0.7
	C	3.0		0.6	0.8	1.5	1.7	2.1
Defects introduced per 1000 lines	D	4.0	0.2	0.3	1.0	2.0		2.8
	E	10.0	0.6	2.0	2.5		5.5	7.0
	F	18.0	1.1	3.6	4.5	9.0	9.9	

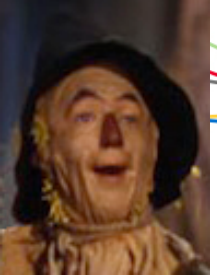
Difficult Function

6. Minimize the Number of Approvers

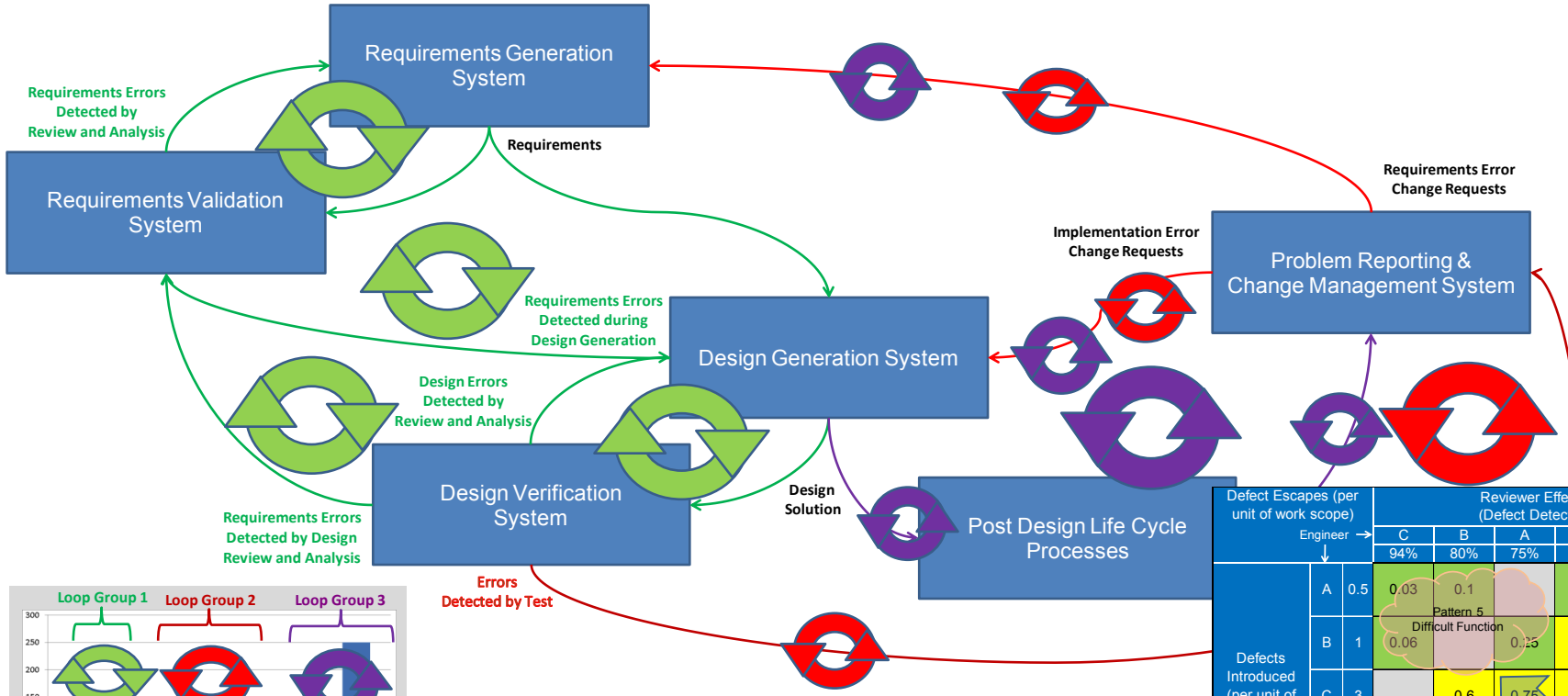
7. Clarify Who is Approving What

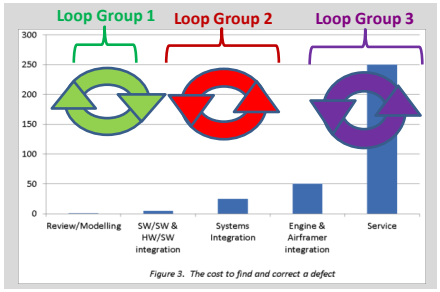


8. Parallel, Not Sequential Approvals



Requirements Validation and Design Verification Pattern Model





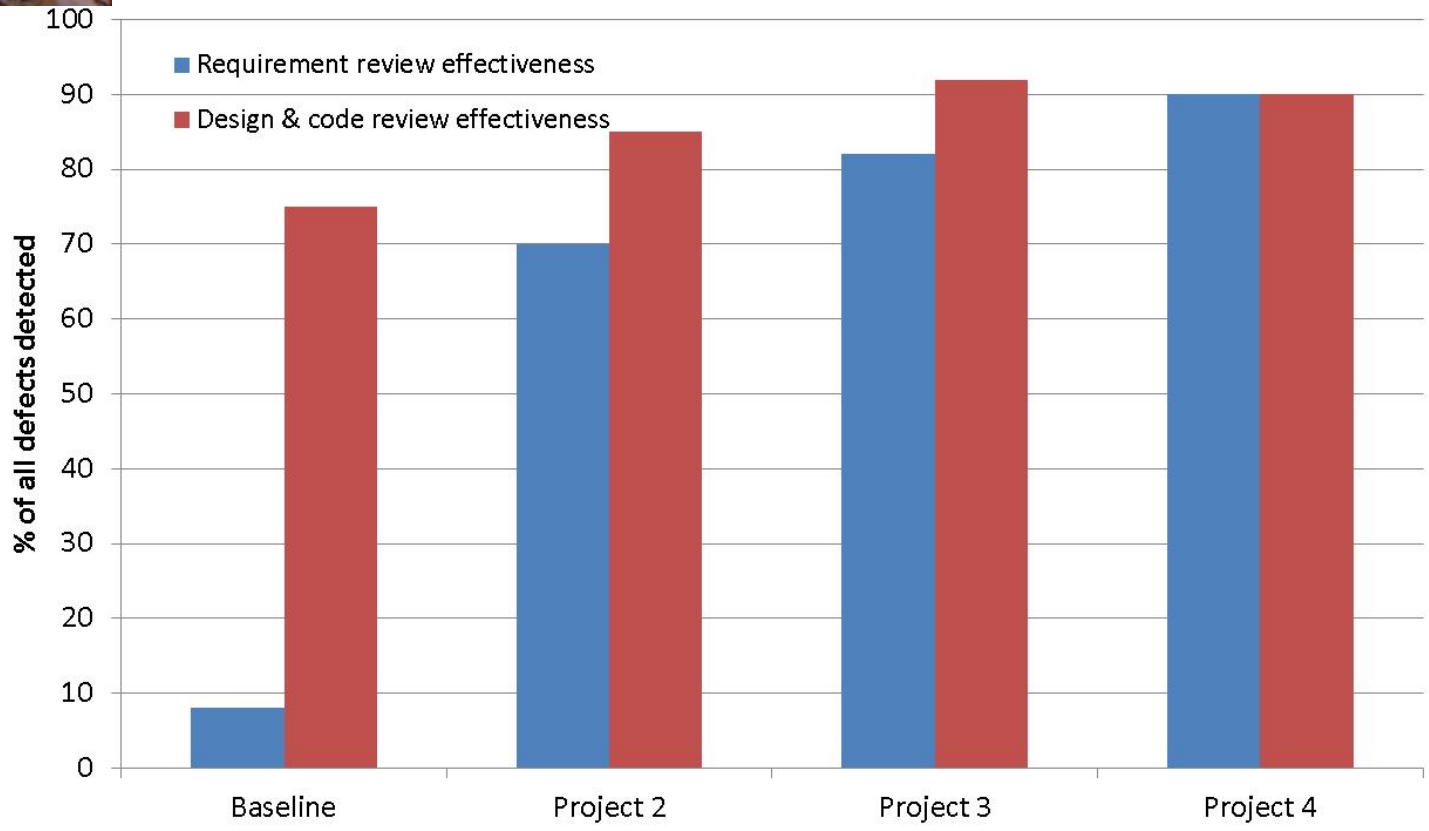
Error introduction and detection "loops" – The basis of a Pattern Based Systems Engineering model of the Requirements Validation and Design Verification Process

Defect Escapes (per unit of work scope)			Reviewer Effectiveness (Defect Detection Rate)					
Engineer →			C	B	A	E	D	F
			94%	80%	75%	50%	45%	30%
Defects Introduced (per unit of Work Scope; e.g. for software, per 1000 lines of code)	A	0.5	0.03	0.1		0.25	0.275	0.35
	B	1	0.06		0.25	0.5	0.55	0.7
	C	3		0.6	0.75	1.5	1.65	2.1
	D	4	0.24	0.8	1			2.8
	E	10	0.6	2	2.5		5.5	7
	F	15	0.9	3	3.75	7.5	8.25	

Pattern 5 Difficult Function

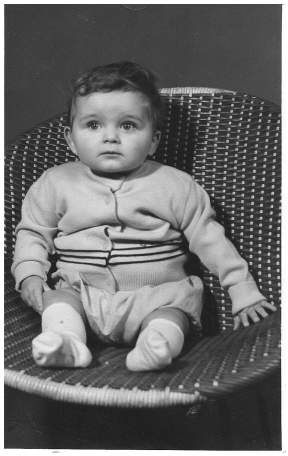
Pattern 2 - Go Green!

Conclusions



Before → 1st usage → 2nd usage → 3rd usage

Everyone has a place on the team. Everyone has the chance to learn & grow

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Apply Characteristics to Tasks