Total Control Over Human Error

A Reliability Model

ICOMS 2008 Conference

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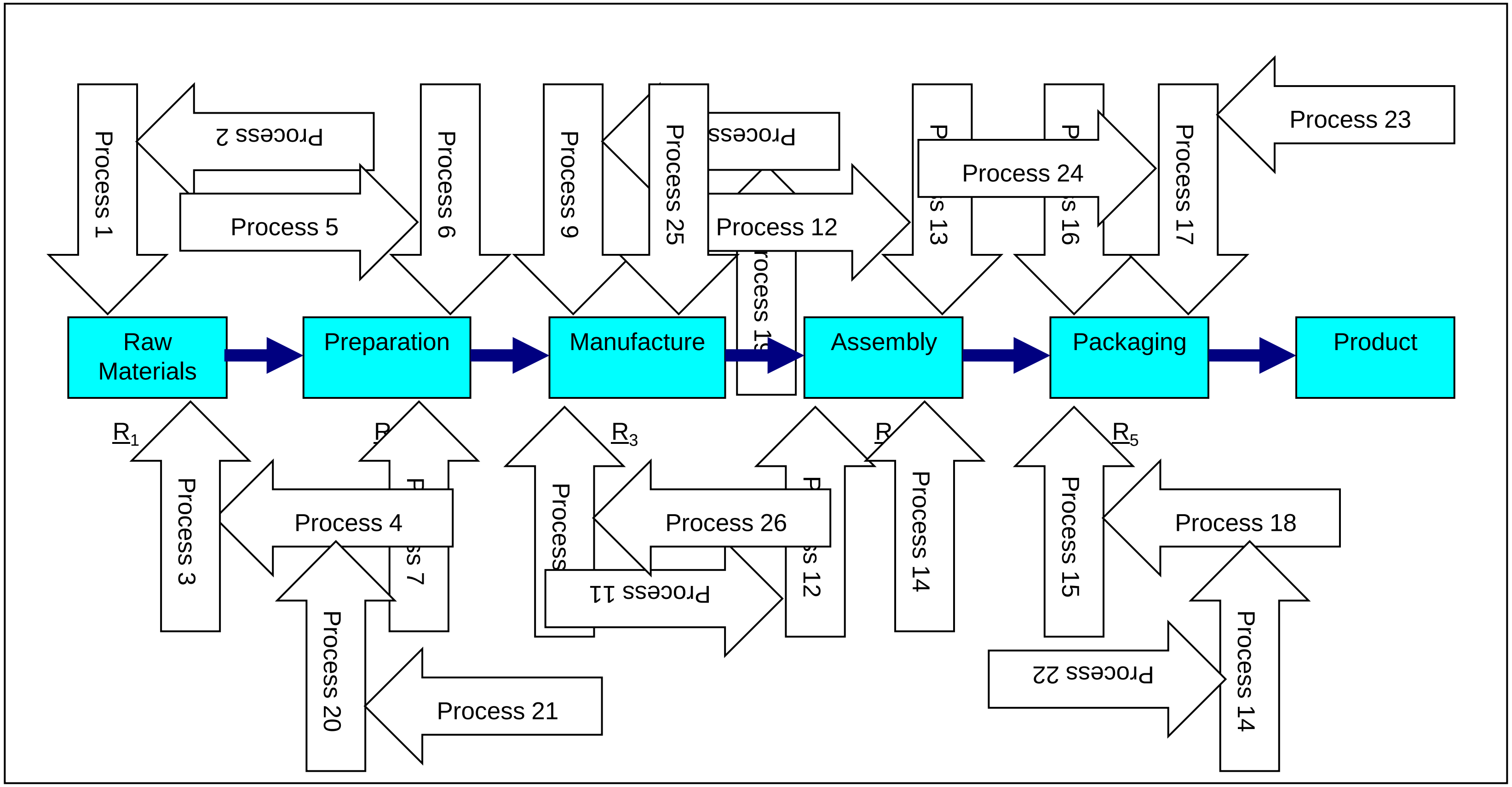
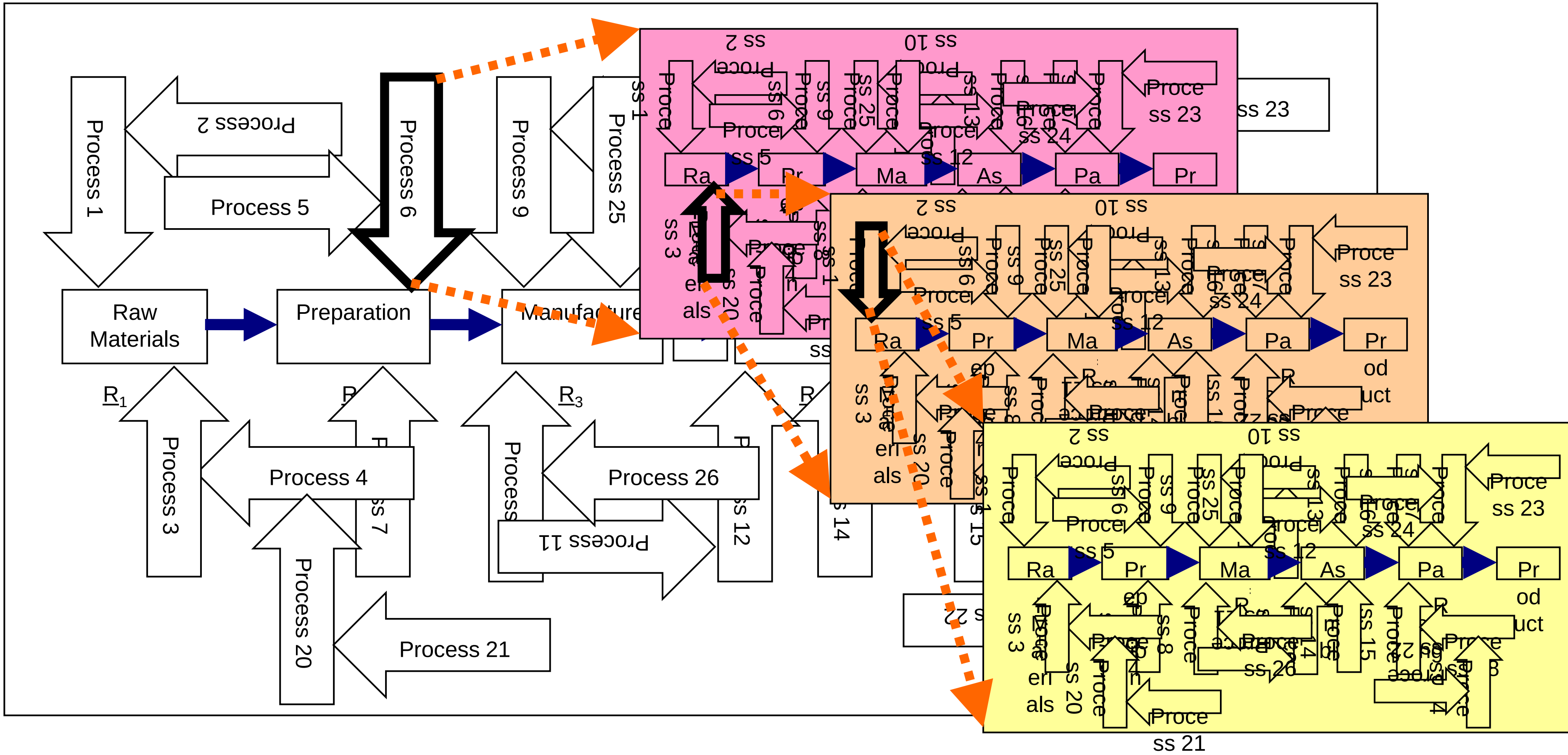
Each Process is Part of a Series of Processes



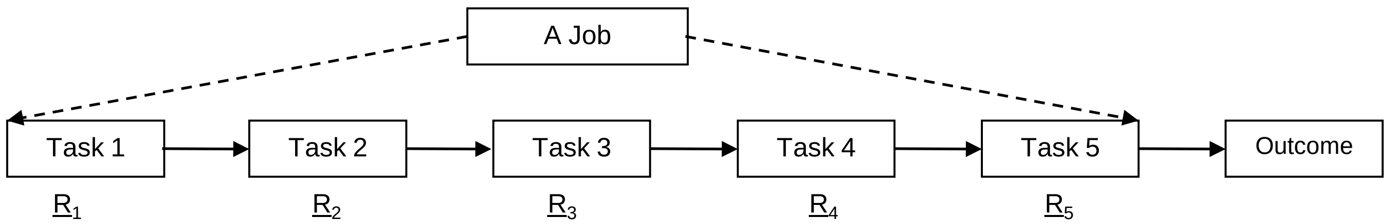
All business processes involve a series of work processes

The Process Chains the Bind Us



Hundreds of activities across dozens of processes – what chance have you got?

Work Process Reliability



$$\underline{R}_{job} = \underline{R}_1 \times \underline{R}_2 \times \underline{R}_3 \times \underline{R}_4 \times \underline{R}_5 \qquad \textit{Eq. 1}$$

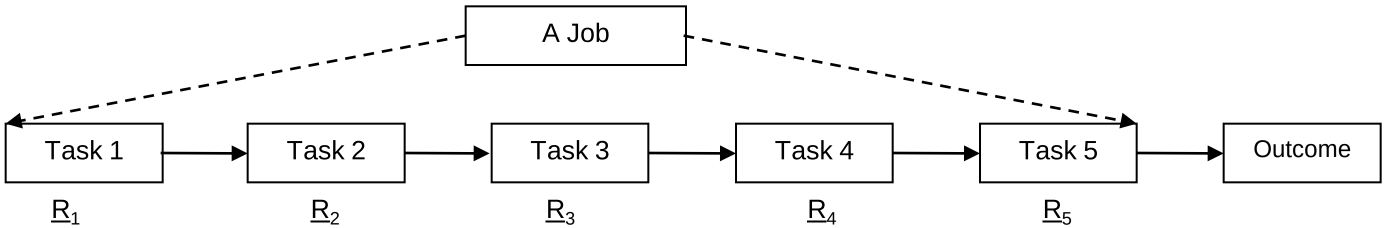
How well a job is done is a simple matter of chance

What is the Chance of Good Work

No	Situation and Task		Error Rate (per task)	Reliability Rate
1	***Routine simple tasks***	Read checklist or digital display wrongly	0.001	0.999
2		Check for wrong indicator in an array	0.003	0.997
3		Fail to correctly replace printed circuit board (PCB)	0.004	0.996
4		Wrongly carry out visual inspection for a defined criterion (e.g. leak)	0.003	0.997
5		Select wrong switch among similar	0.005	0.995
6		Read 10-digit number wrongly	0.006	0.994
7	***Routine task with care needed***	Wrongly replace a detailed part	0.02	0.98
8		Put 10 digits into a calculator wrongly	0.05	0.95
9		Do simple arithmetic wrong	0.01 - 0.03	0.99 – 0.97
10		Read 5-letter word with poor resolution wrongly	0.03	0.97
11		Dial 10 digits wrongly	0.06	0.94
12		Punch or type character wrongly	0.01	0.99
13	***Complicated, non-routine task***	Fail to notice incorrect status in roving inspection	0.1	0.9
14		New work shift – fail to check hardware, unless specified	0.1	0.9
15		High stress, non-routine work	0.25	0.75
16		Fail to notice wrong position of valves	0.5	0.5
17		Fail to act correctly after 1 minute in emergency situation	0.9	0.1

Smith, Dr, David J., Reliability, Maintainability and Risk, Seventh Edition, Appendix 6. Elsevier, 2005

The Chance of Doing a Good Job



$$\underline{R}_{job} = \underline{R}_1 \times \underline{R}_2 \times \underline{R}_3 \times \underline{R}_4 \times \underline{R}_5 \qquad \textit{Eq. 1}$$

$\underline{R}job = 1 \times 1 \times 0.6 \times 1 \times 1 = 0.6$ (or 60%) — 'One poor, all poor'

$\underline{R}job = 0.9 \times 0.9 \times 0.9 \times 0.9 \times 0.9 = 0.59$ (or 59%) — For a 0.9 maintenance job

$\underline{R}job = 0.75 \times 0.75 \times 0.75 \times 0.75 \times 0.75 = 0.237$ (or 24%) — Maintenance with stress

It is human error permitted by bad work process design that makes our series arranged processes so unreliable.

…is a Series Work Process

Task 1 → Task 2 → Task 3 → Task 4 - - - - - - - - - → Task 10 → Task 11 → Task 12

The Work Environment

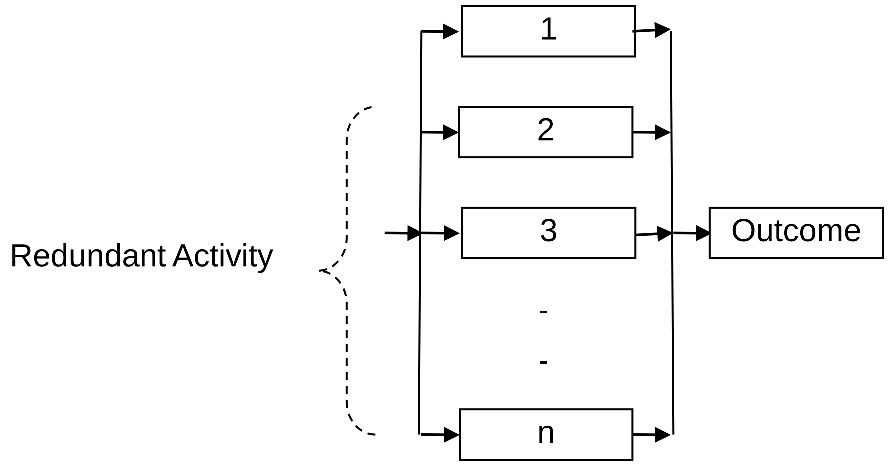
1	2	3	4	5	6	7	8	9	10	11	12
R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}

What is the chance of all 12 tasks being done 100% perfectly?

What if there were 50 tasks in a job?

A Parallel Arrangement

Fortunately reliability principles also give us the answer to the problems with series processes – the parallel process

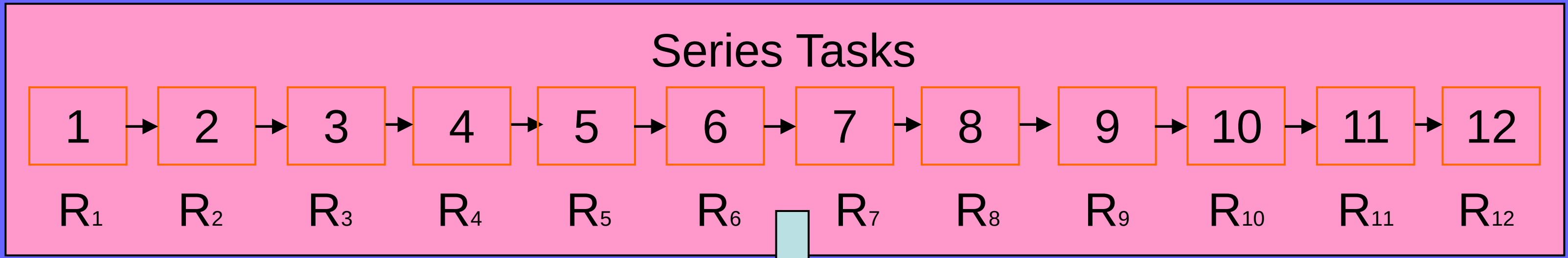


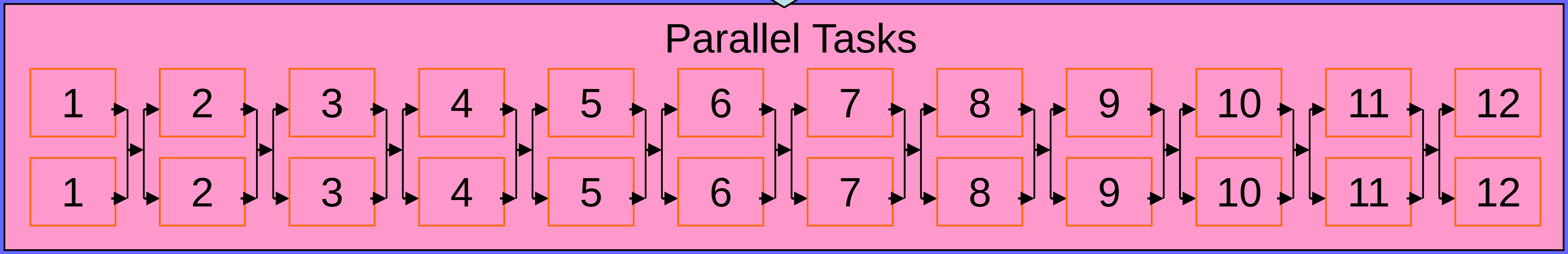
$$\mathbf{R_{para} = 1 - [(1-R_1) \times (1-R_2) \times \ldots.(1-R_n)]} \qquad \textit{Eq. 2}$$

$R_{para} = 1 – [(1-0.6) \times (1-0.6) \times (1-0.6) \times (1-0.6)]$
$= 1 – [(0.4) \times (0.4) \times (0.4) \times (0.4)] = 1 – [0.0256]$
$= 0.9744$ (i.e. 97.4%)

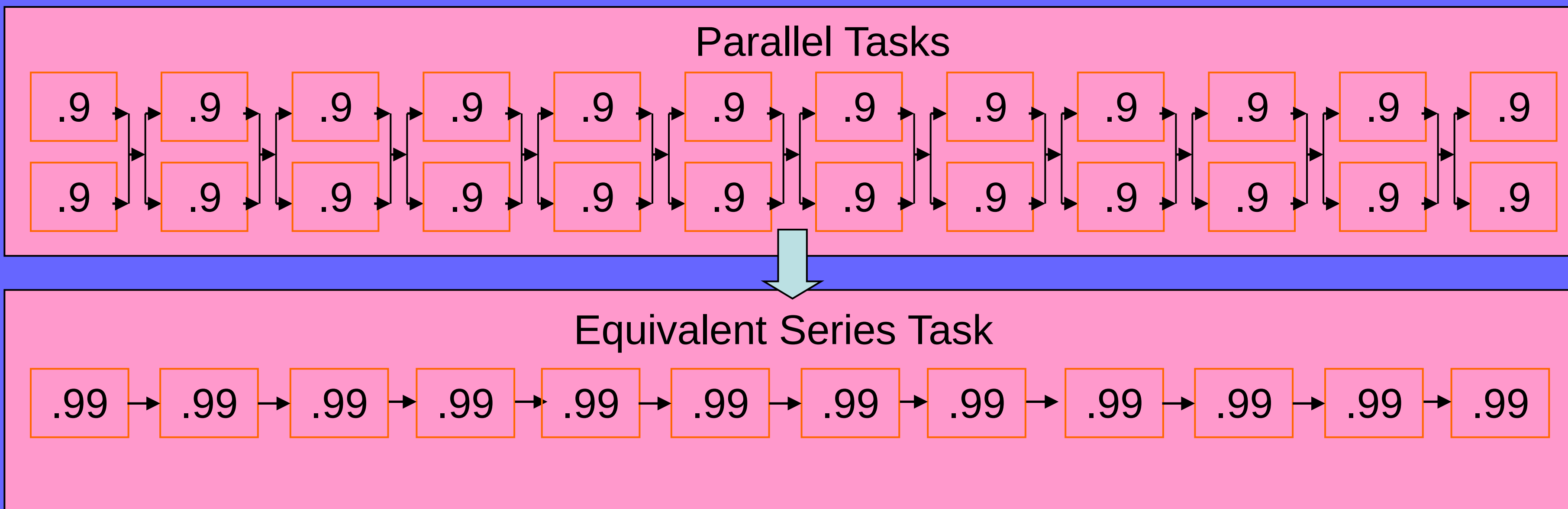
Parallel four poor chances and your odds improve, because not all go wrong at the same time

- *Can each task be made more certain? … How certain?*
- *Can we include redundancy and turn tasks into a parallel arrangement? …*





Parallel Process Reliability



Parallel System

$R_{system} = 1- [(1- R_1)x(1- R_2)x(1-R_3) \ldots.]$

$1- [(1- 0.9)x(1- 0.9)]$

$1- [0.1 \times 0.1]$

$1- [0.01] = 0.99$

Series System

$R_{system} = R_1 \times R_2 \times R_3 \ldots.$

$0.99 \times 0.99 \times \ldots 0.99$

$(0.99)^{12} = 0.8864$

If 50 tasks $(0.99)^{50} = 0.6$

Without Parallel Test

$R_{system} = R_1 \times R_2 \times R_3 \ldots$

$0.9 \times 0.9 \times \ldots 0.9$

$(0.9)^{12} = 0.2824$

If 50 tasks $(0.9)^{50} = 0.0052$

We need 0.9999

12 task series process:

$R_{system} = R_1 \times R_2 \times R_3 \ldots$

0.9999 x 0.9999 x … 0.9999

$(0.9999)^{12}$

0.9988 (~ 1 error in 1000 tasks – ~ 4.5σ)

50 task series process:

$R_{system} = R_1 \times R_2 \times R_3 \ldots$

0.9999 x 0.9999 x … 0.9999

$(0.9999)^{50}$

0.995 (5 errors in 1000 tasks – ~ 4σ)

0.999 is not enough

12 task series process:

$R_{system} = R_1 \times R_2 \times R_3 \ldots$

0.999 x 0.999 x … 0.999

$(0.999)^{12}$

0.9881 (~ 1 error in 100 tasks – ~ 3.5σ)

50 task series process:

$R_{system} = R_1 \times R_2 \times R_3 \ldots$

0.999 x 0.999 x … 0.999

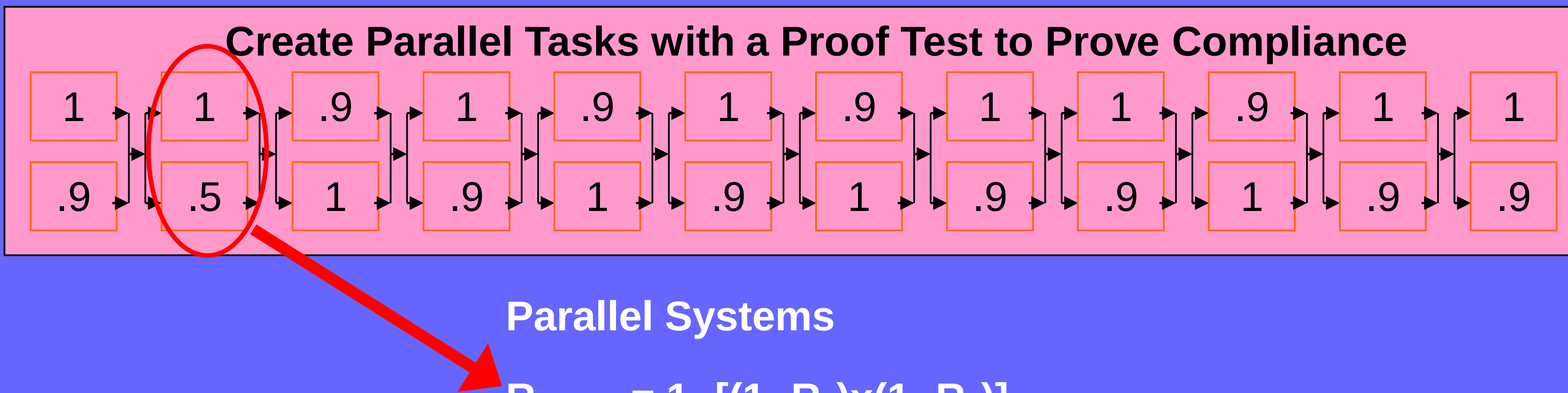
$(0.999)^{50}$

0.95 (5 errors in 100 tasks – ~ 3σ)

How do we get maintenance tasks to be 0.9999 reliable, when …

… they don't make 0.99 reliable peoples?

Something else is interesting with parallel tasks …



Parallel Systems

$$R_{system} = 1 - [(1 - R_1) x (1 - R_2)]$$

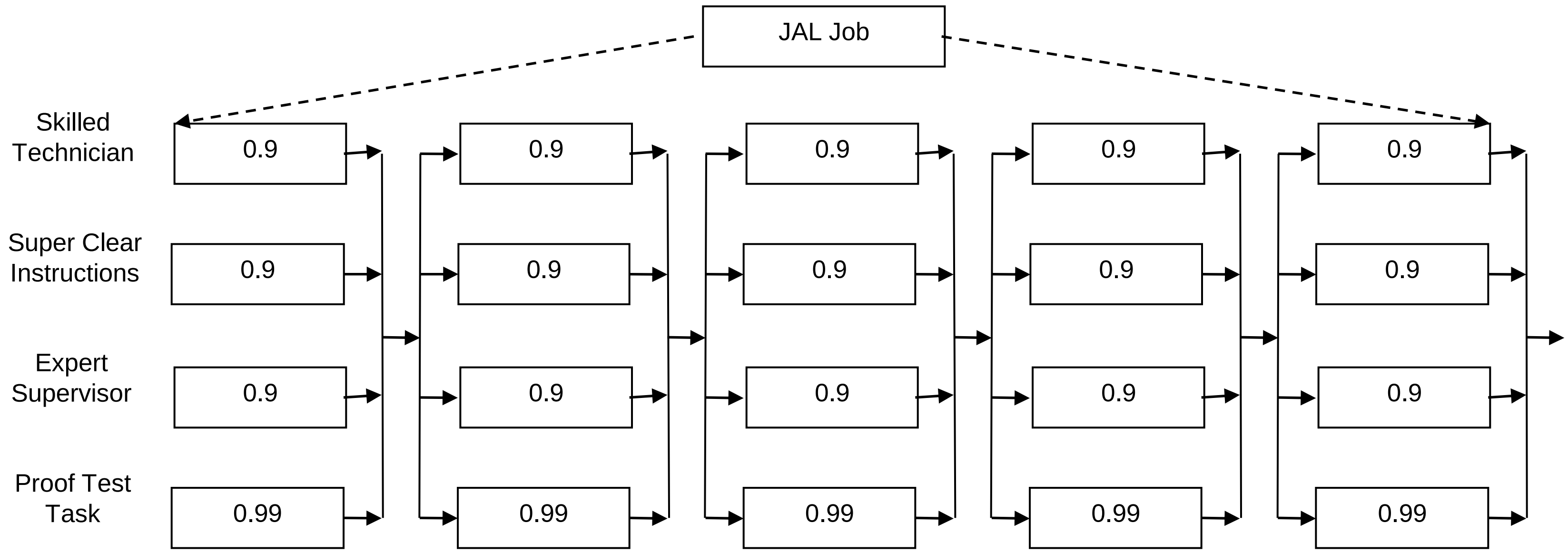
$$1 - [(1 - 1) x (1 - 0.5)]$$

$$1 - [0 x 0.5]$$

$$1 - [0] = 1$$

As long as one parallel task is done right … the whole step is right – *100% right*!

The J.A.L. Job



$R_{task} = 1 – [(1-0.9) \times (1-0.9) \times (1-0.9) \times (1-0.99)]$

$= 1 – [(0.1) \times (0.1) \times (0.1) \times (0.01)]$

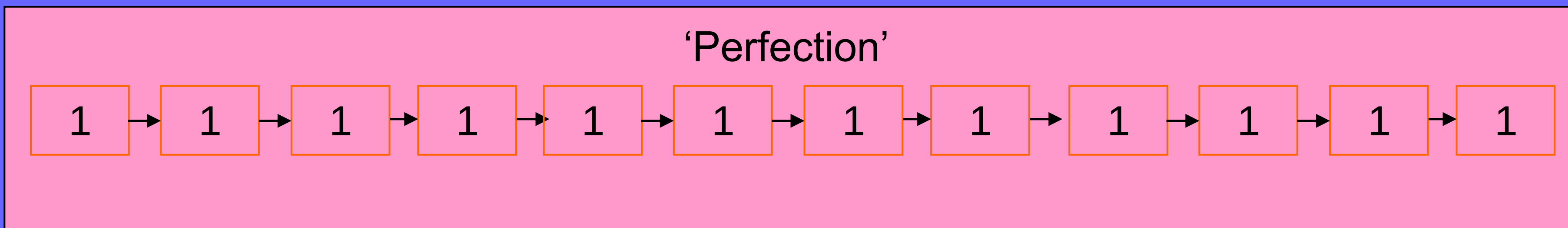
$= 0.99999$ (i.e. 99.999%, or 1 error per 100,000 opportunities)

$R_{job} = 0.99999 \times 0.99999 \times 0.99999 \times 0.99999 \times 0.99999 = 0.99995$ (i.e. 99.995%)

The error rate for the whole job is now 5 errors per 100,000 opportunities.

How well a job is done is a simple matter of **controlling** chance

But the best answer is to failure proof the job design …



Failure-Proofed Series Systems

$$R_{system} = R_1 \times R_2 \times R_3 \ldots$$

$$1 \times 1 \times \ldots 1$$

$$(1)^{12} = 1$$

$$(1)^{50} = 1$$

… and get each task *100% right - always perfect*!

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