Architectural Approaches for using COTS Components in Critical Applications

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Pros and Cons of COTS Components [Arlat *et al.* 2000]

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  - Often de facto standards
  - Lower development cost
  - Shorter development time
  - Rapid incorporation of technological progress
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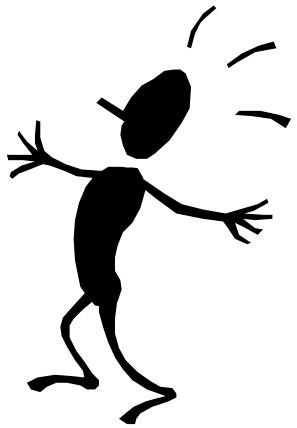

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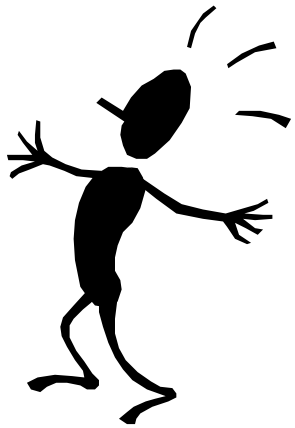

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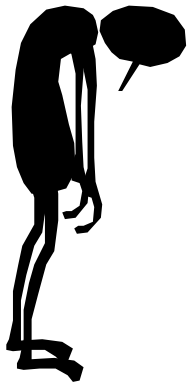
- No guarantee of continued support from supplier
- No guarantee of compatibility of successive versions
- Little objective information about the component itself or its development process
- Component may not be well-adapted to requirements
- Inheritance of unwanted or even unknown functions
- Uncertain quality



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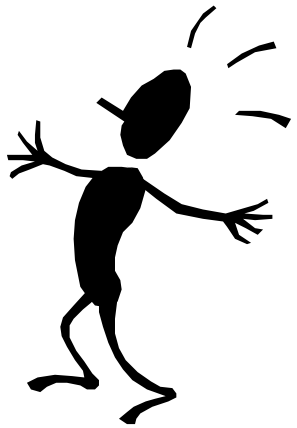

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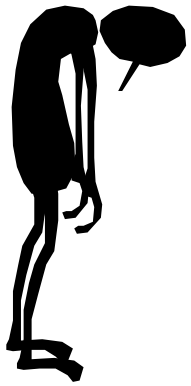

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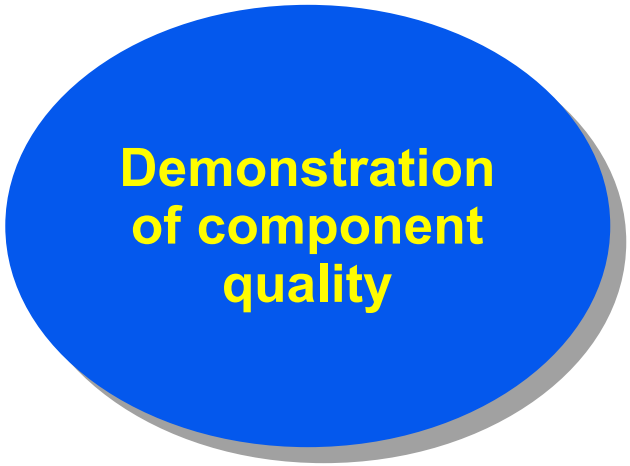

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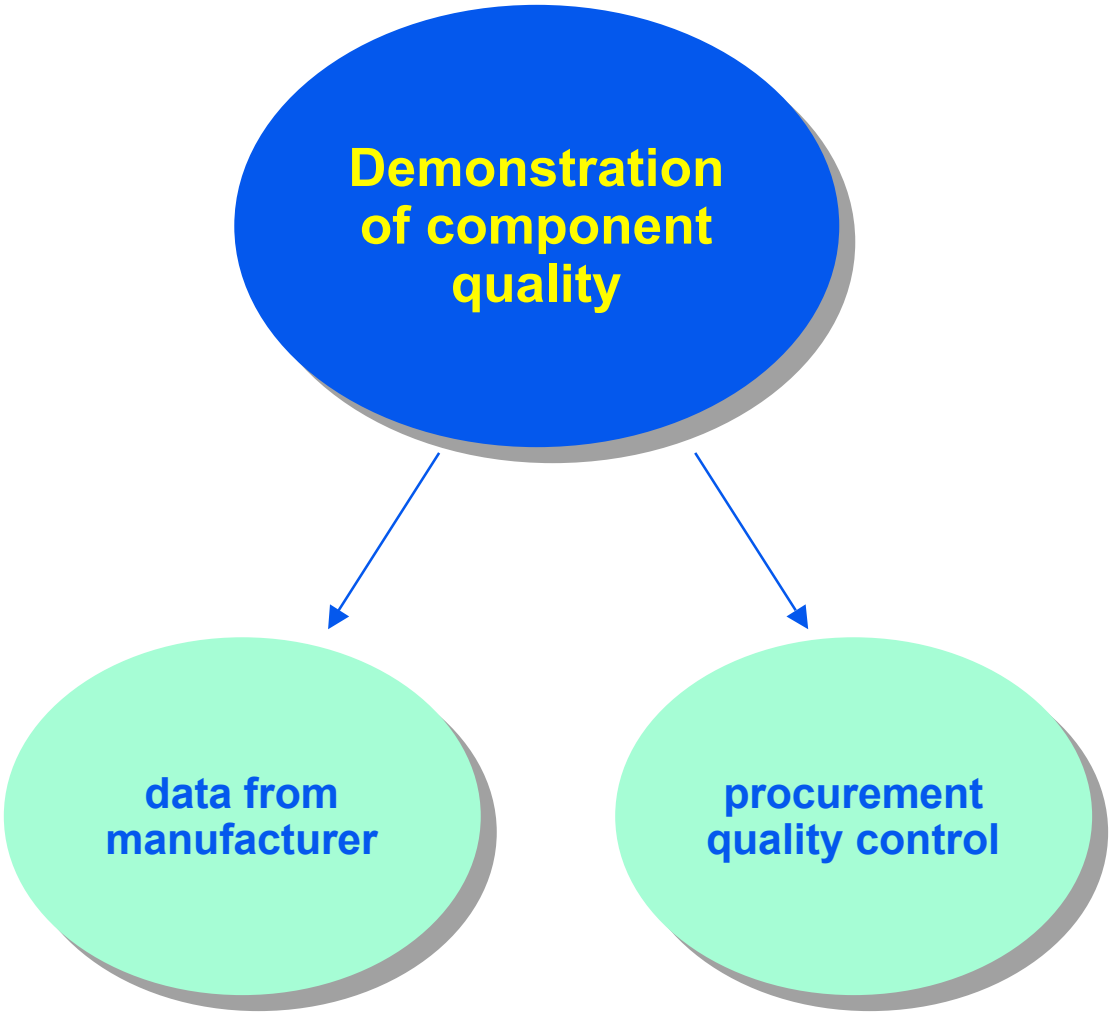

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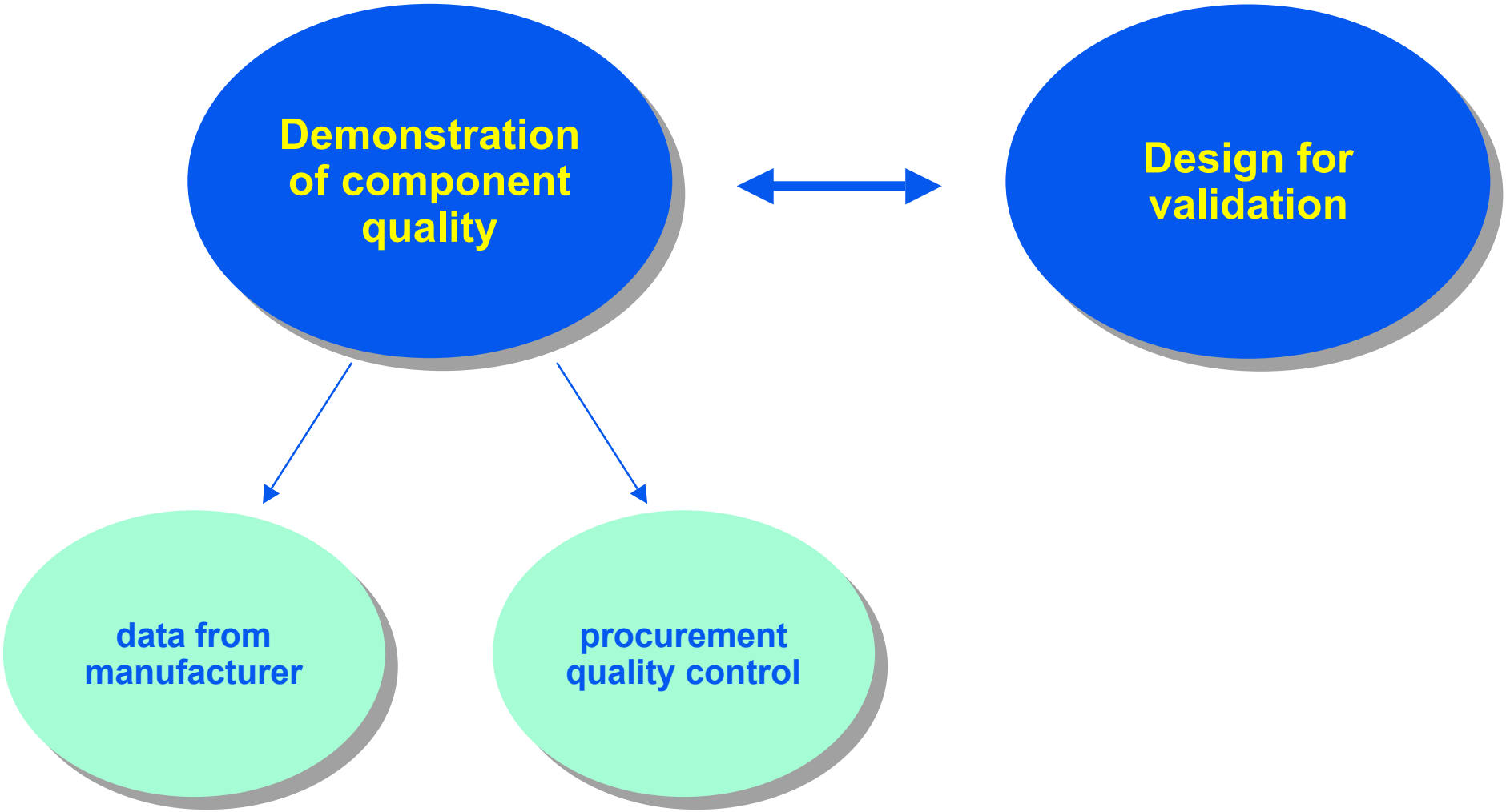

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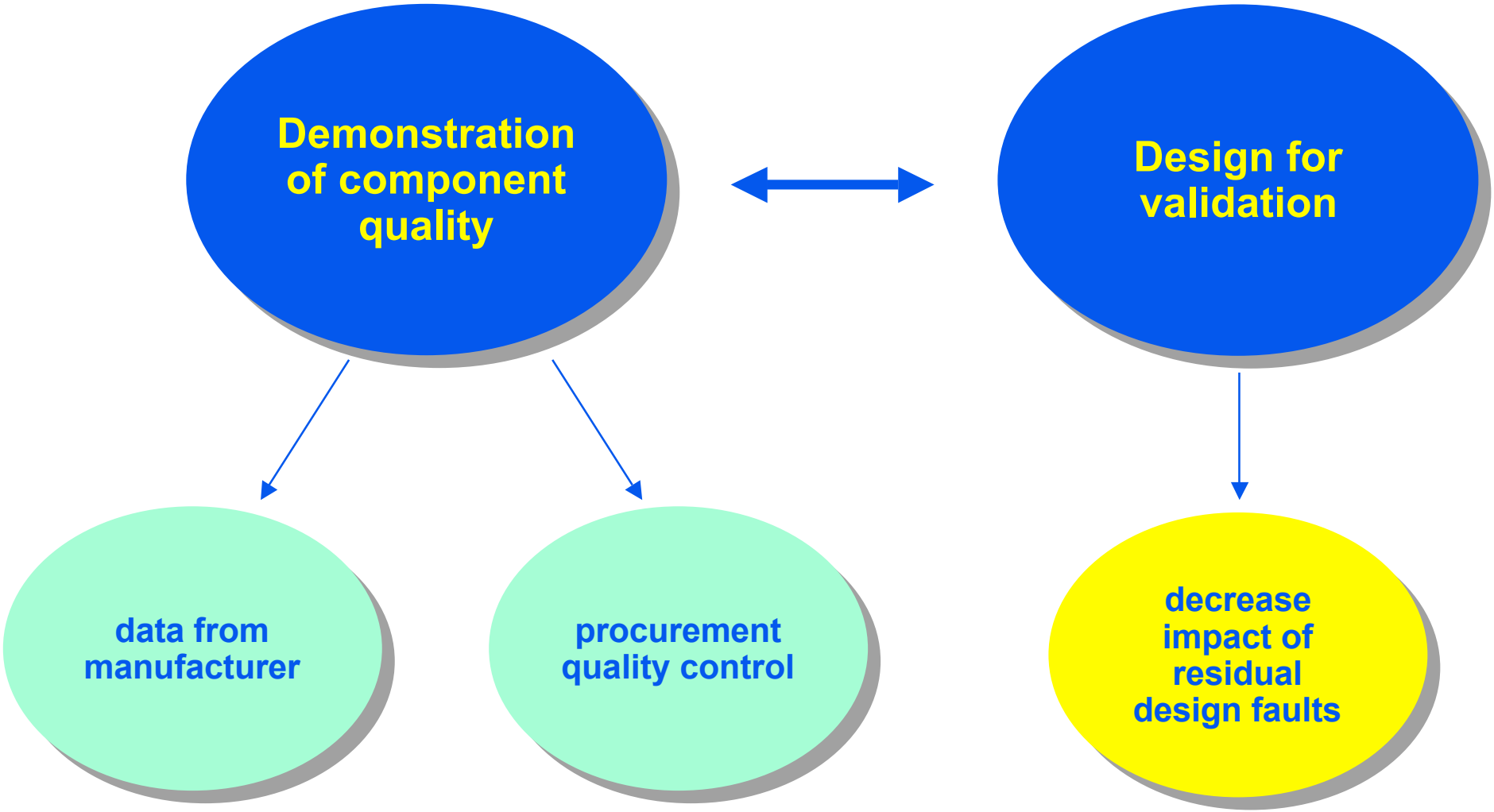

Designing Critical Systems

- Functional decomposition
- Categorise functions according to their criticality, i.e., in terms of the consequences of function failure
  - ➥ e.g. [DO-178B] — catastrophic, dangerous, major, minor, no effect
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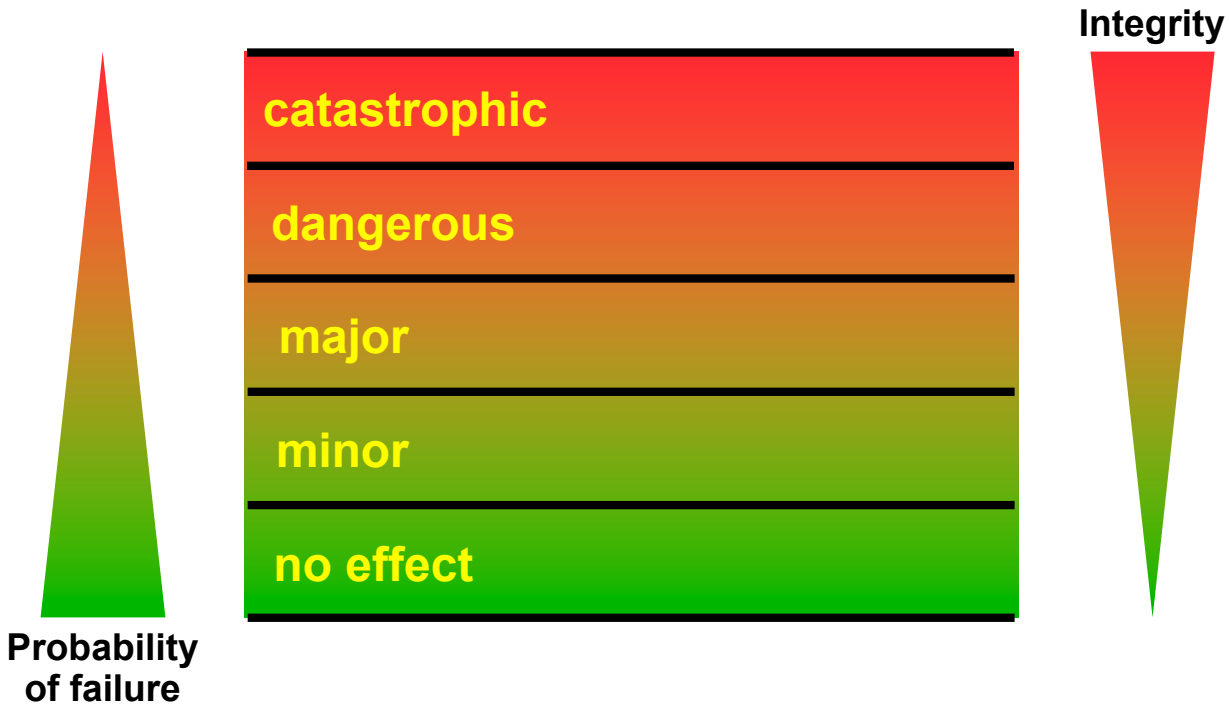

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  - ➥ Replication & activation decorrelation
  - ➥ Functionally-independent error detection schemes (inc. diversification)
  - ➥ Partitioning
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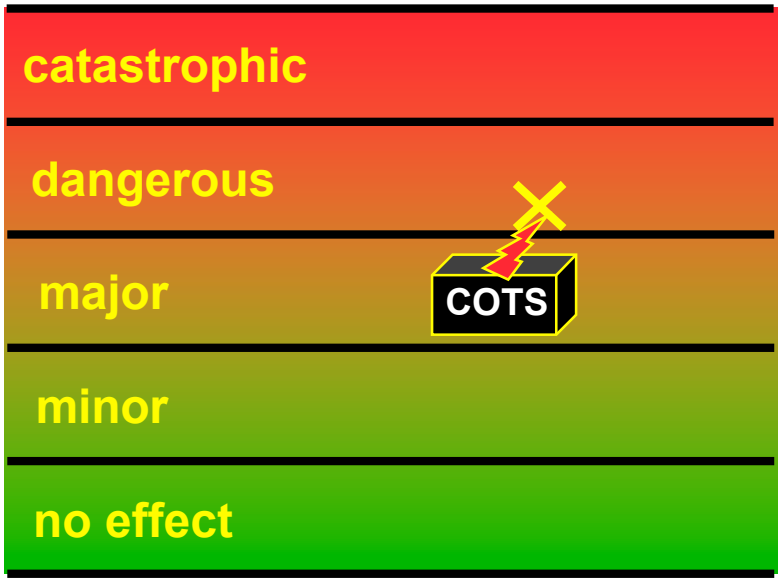

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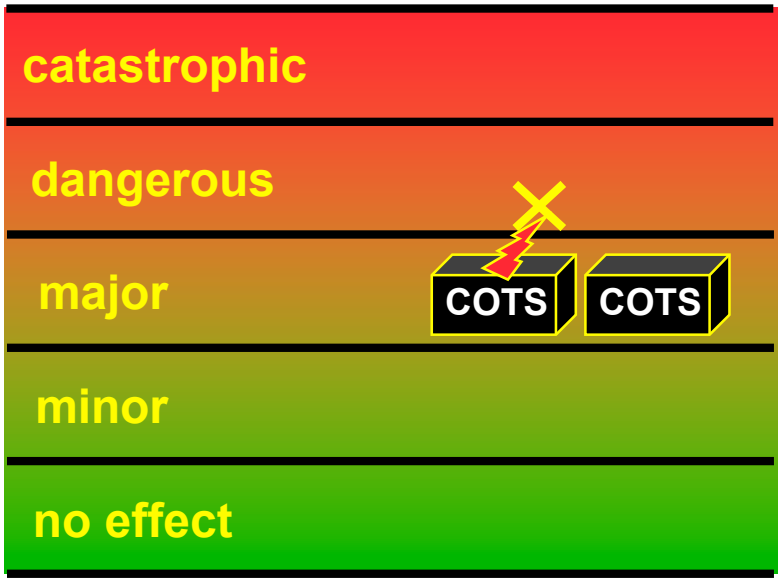

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Replication & Activation Decorrelation

- **Simplest (but least effective) protection against design faults**
- **Principle**
  - ➥ ***Residual* design faults have activation conditions depending on subtle combinations of internal system states**
    - ➢ ***popularised through the term* Heisenbugs**
  - ➥ **Can use identical redundant components if activation conditions are sufficiently decorrelated**
- **Examples:**
  - ➥ **Re-execution of identical tasks in different execution contexts (Tandem)** [Gray 1986]
  - ➥ **Parallel execution of identical tasks in different execution contexts (Elektra)** [Erb 1989, Kantz & Koza 1995]
  - ➥ **Parallel execution of diversified tasks on identical processors (Airbus)** [Brière & Traverse 1993]

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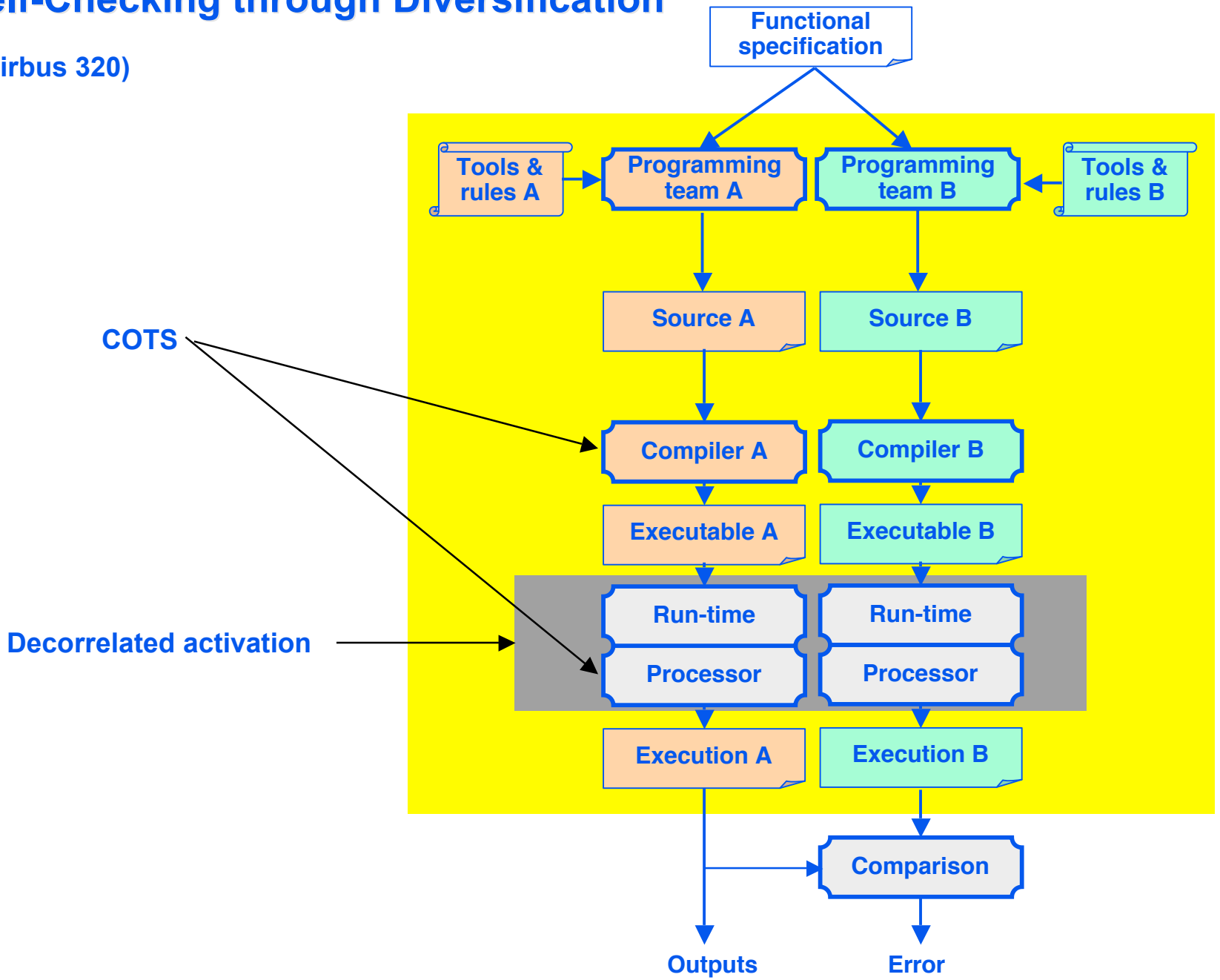
Self-Checking through Diversification

(Airbus 320)



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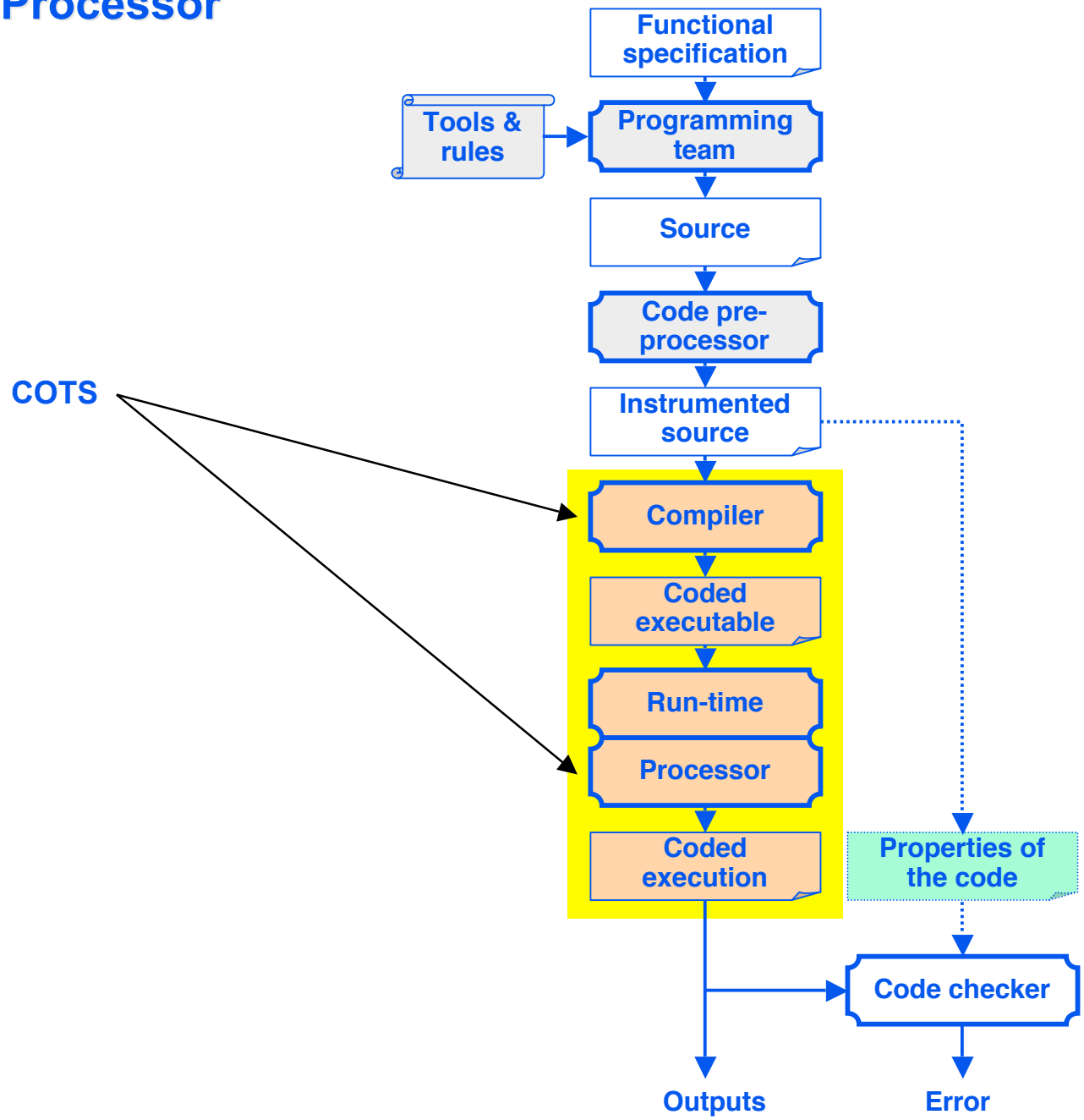
  - ➥ **Signatures for sequencing and addressing errors**

Coded Processor



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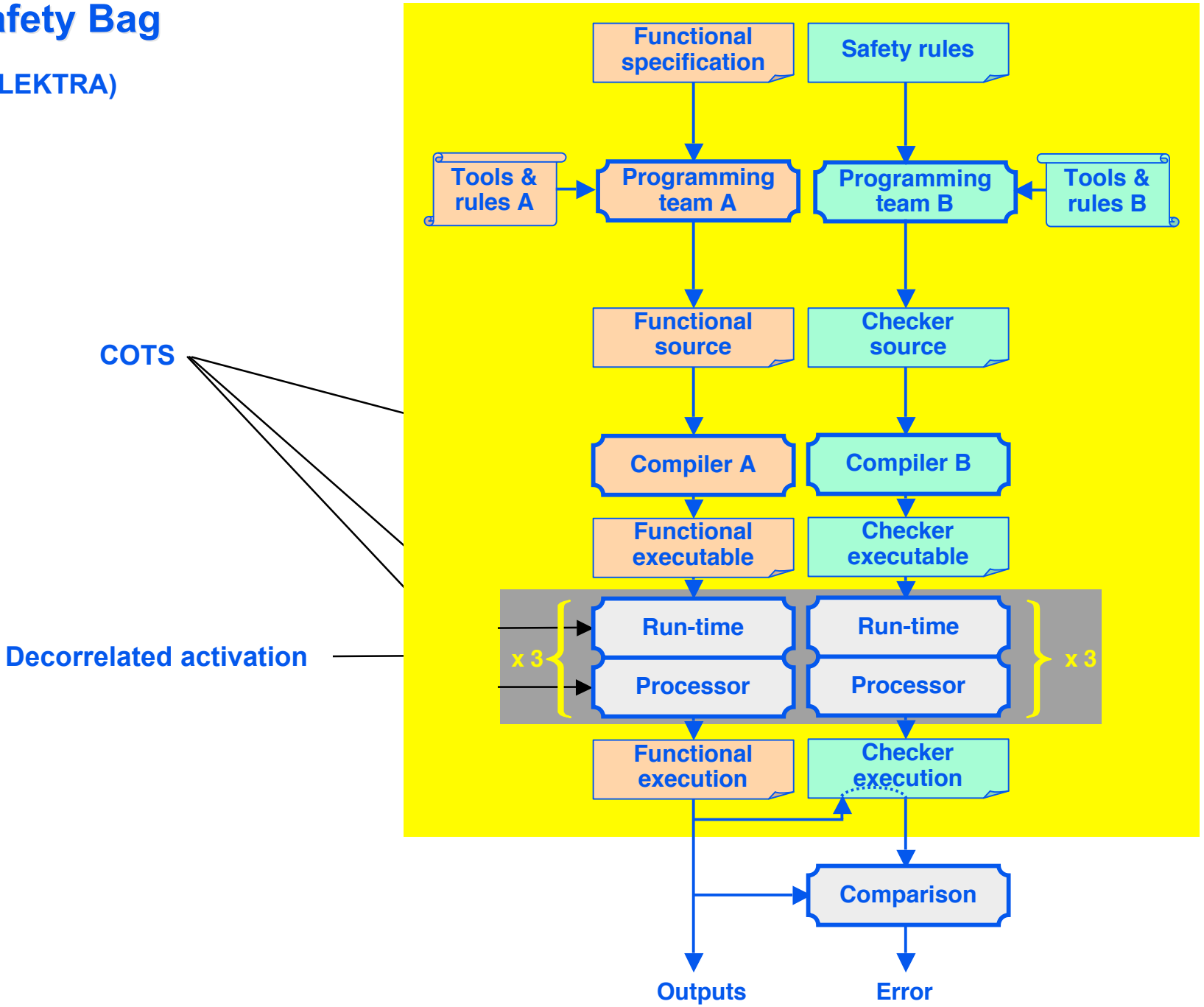
  - **Independent channels for functional computation and checking computation**
  - **Checking computation (acceptance test) consists of executable assertions**

Safety Bag

(ELEKTRA)



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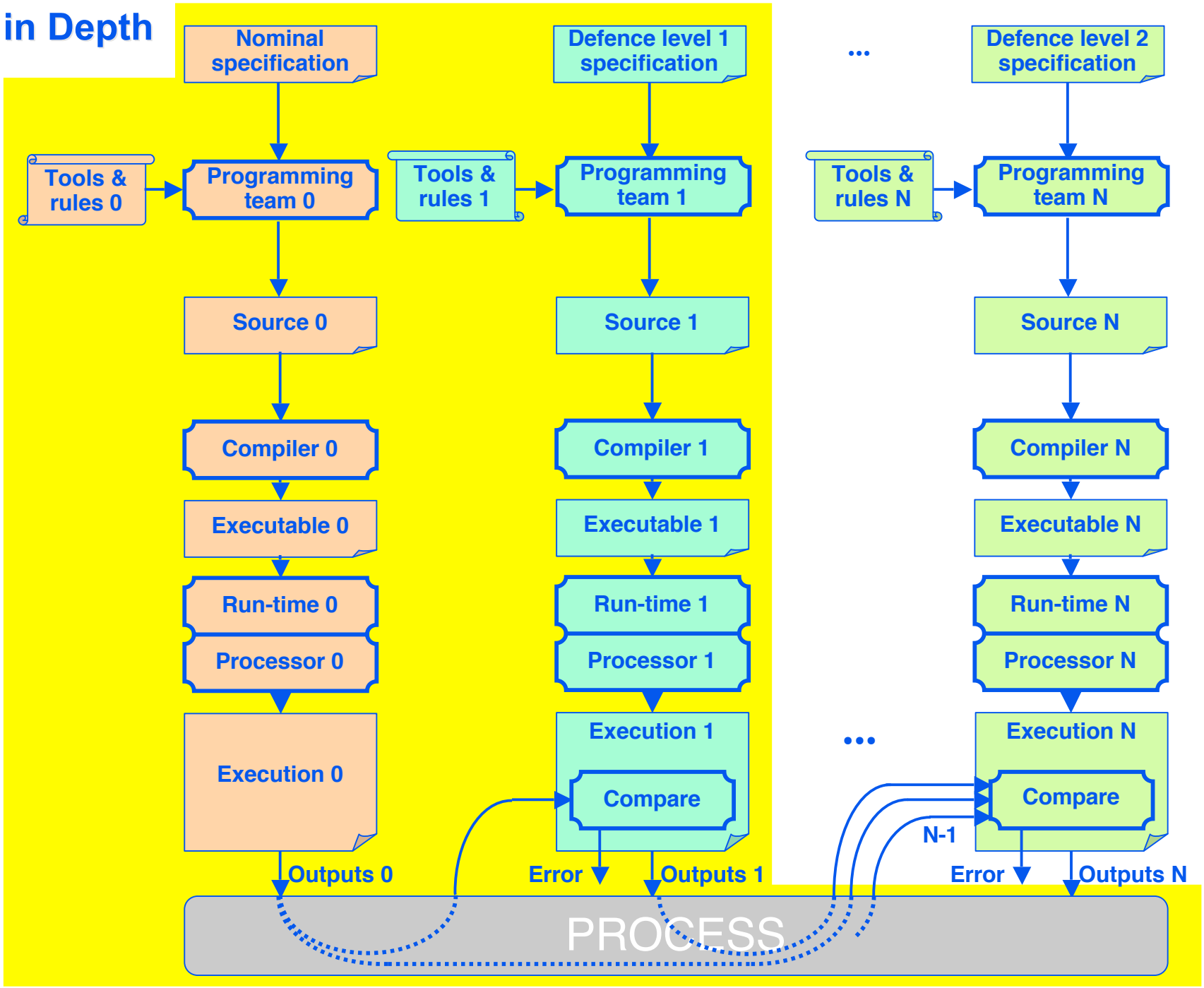
- **Defence in depth**
  - **Hierarchy of control channels with different levels of integrity and service (simpler service => higher integrity)**
  - **Each channel monitors the operation of lower integrity channels**

Defence in Depth



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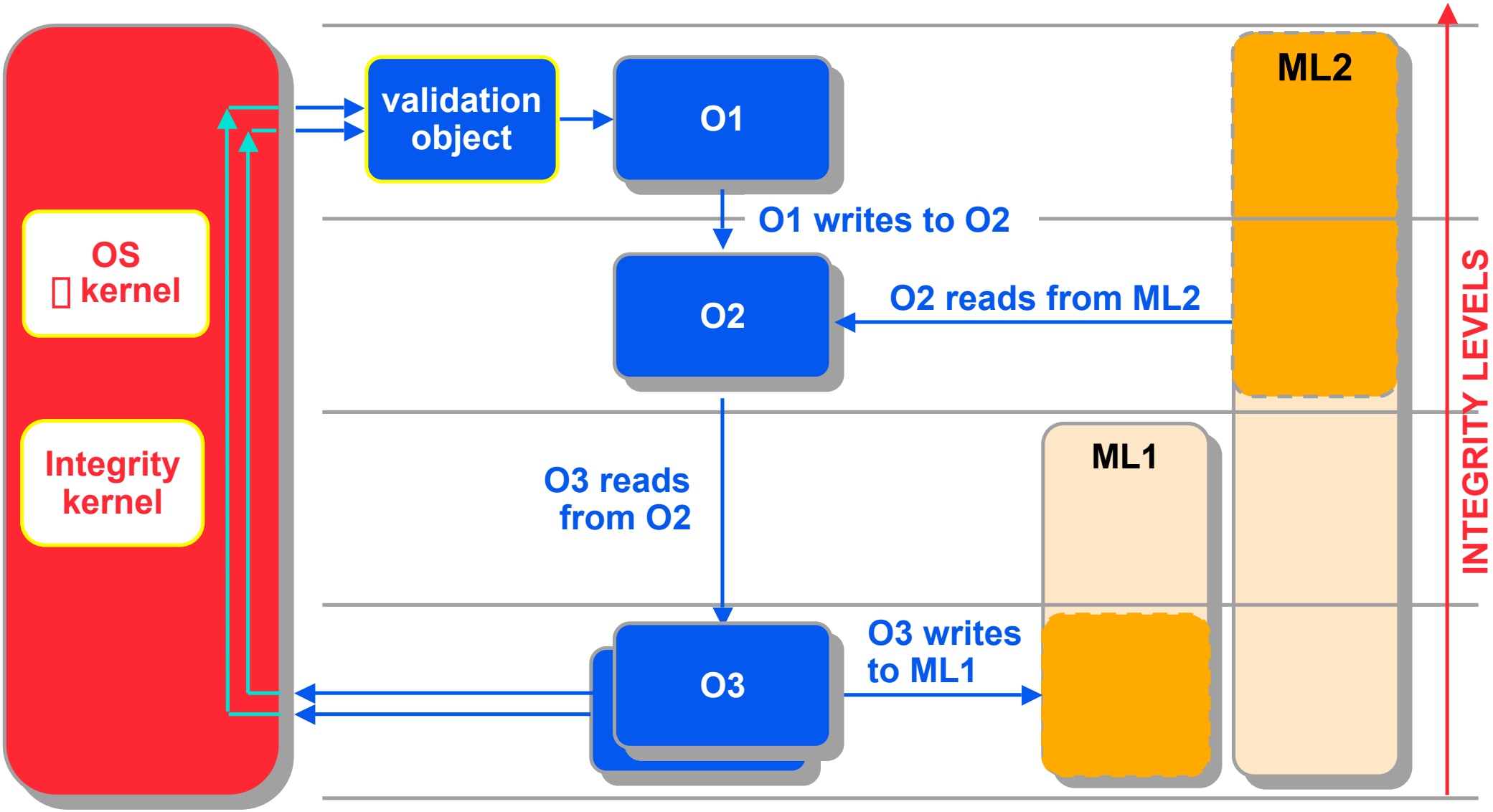
Examples

- Integrated Modular Avionics (IMA)
  - *write-protected memory allocated to processes of a partition*
  - *SAFEbus for time-partitioning access to hardware resources* [Hoyme & Driscol 1992]
- **GUARDS integrity domains** [Totel *et al.* 1998]

GUARDS Integrity Domain Structuring



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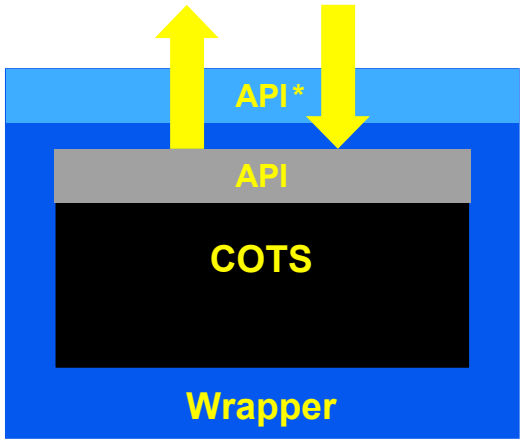

[Salles *et al.* 1999]

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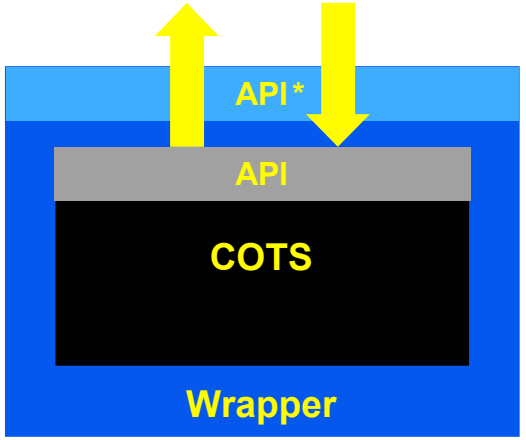

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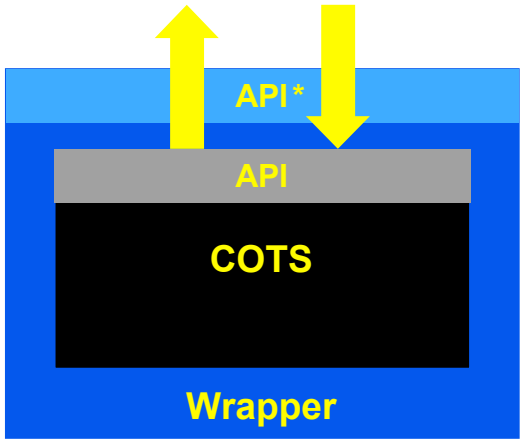

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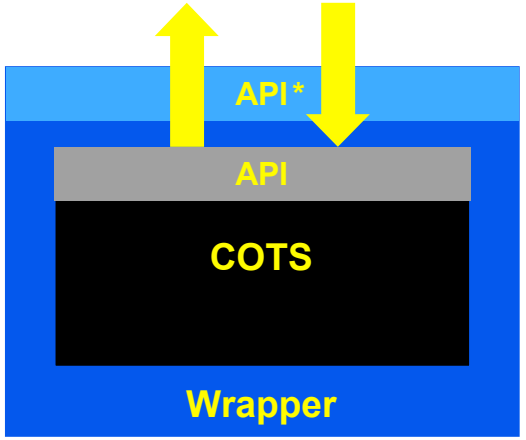

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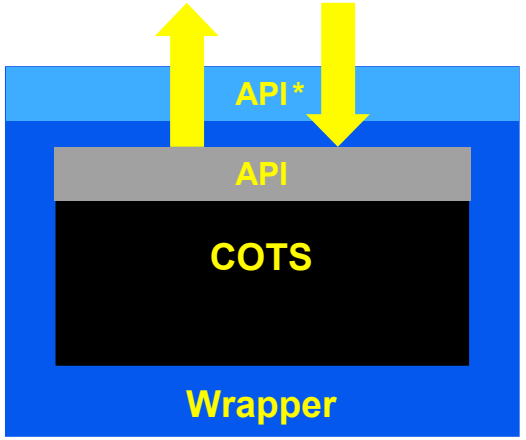

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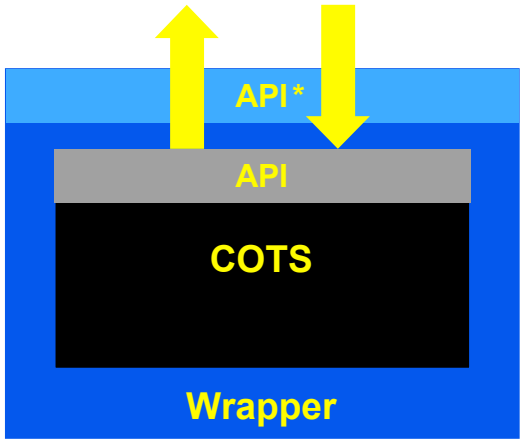

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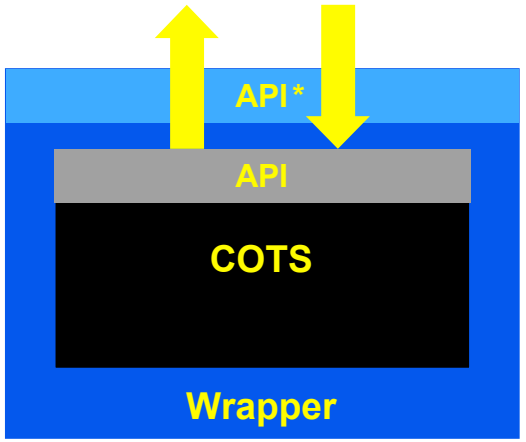

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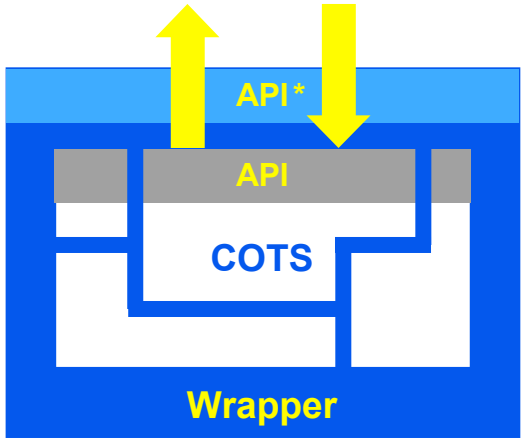

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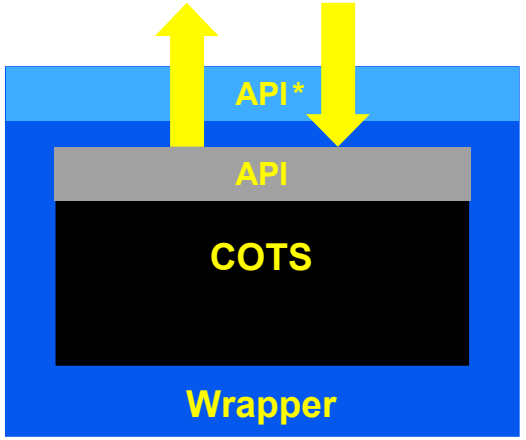

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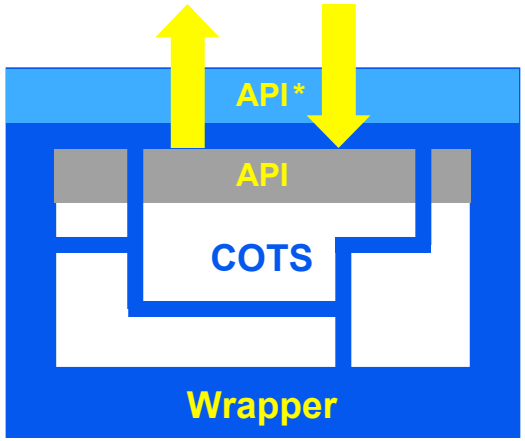
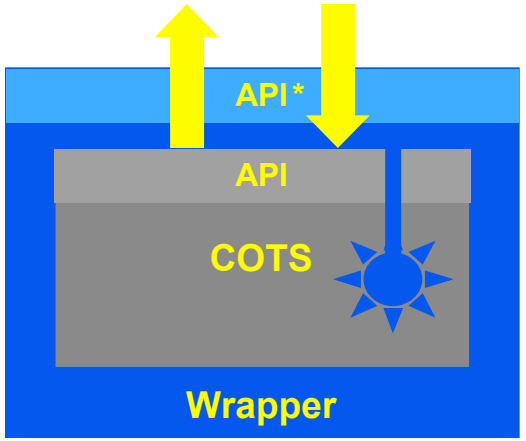


Grey-box COTS
a reflective interface supplied by COTS manufacturer allows *introspection*

[Salles *et al.* 1999]



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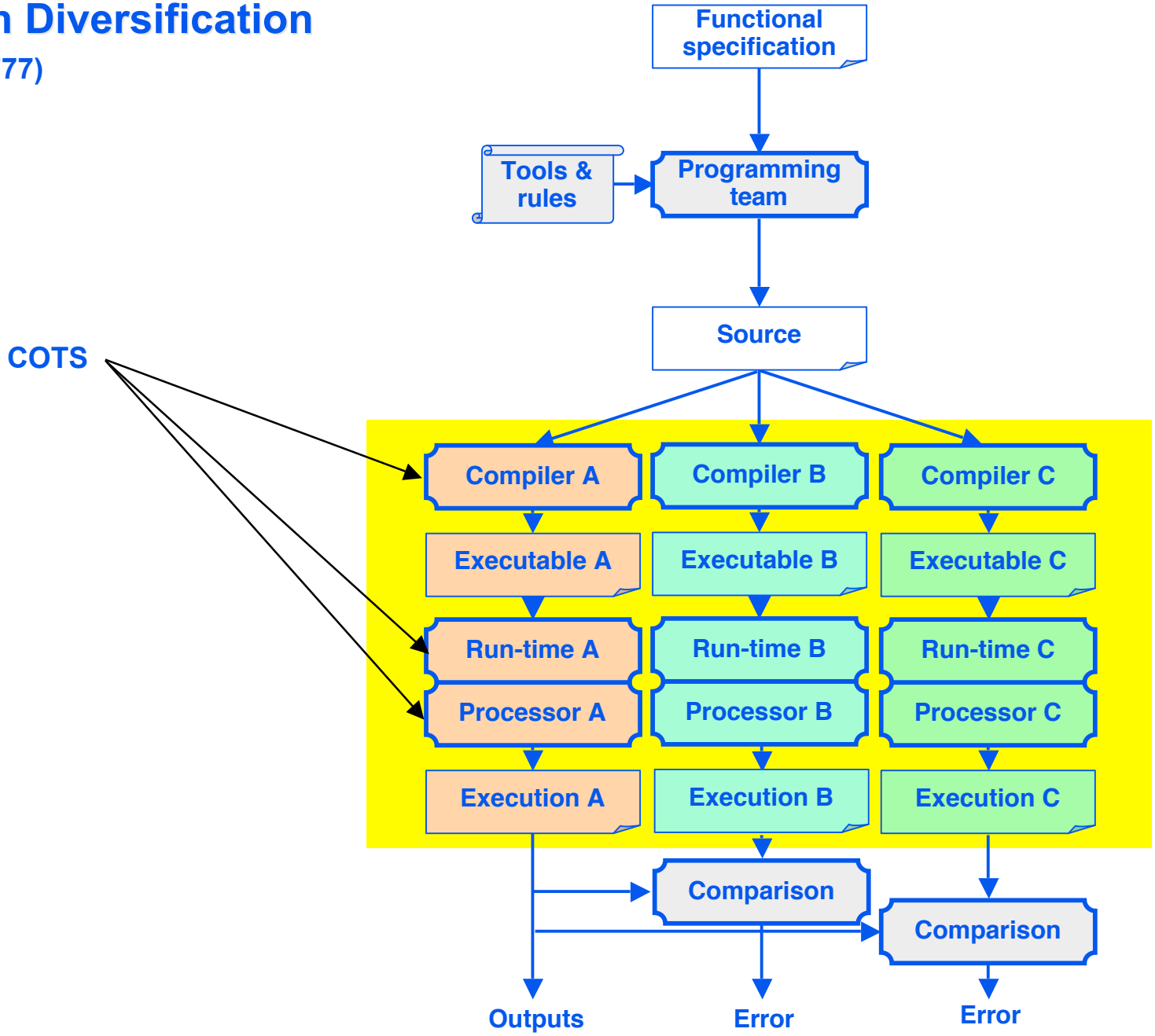
Continued Service through Diversification

(Boeing 777)

[Yeh 1998]



Continued Service through Diversification

(Airbus 320)

Slats & flaps

SFCC1

SFCC2

Pilots

Spoilers

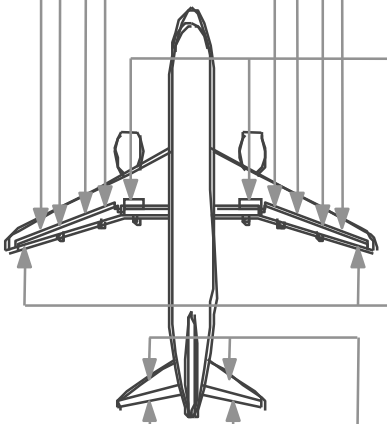
SEC1

Spoilers

SEC2

Spoilers

SEC3



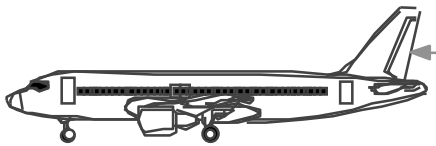
Ailerons

ELAC1

ELAC2

Trim

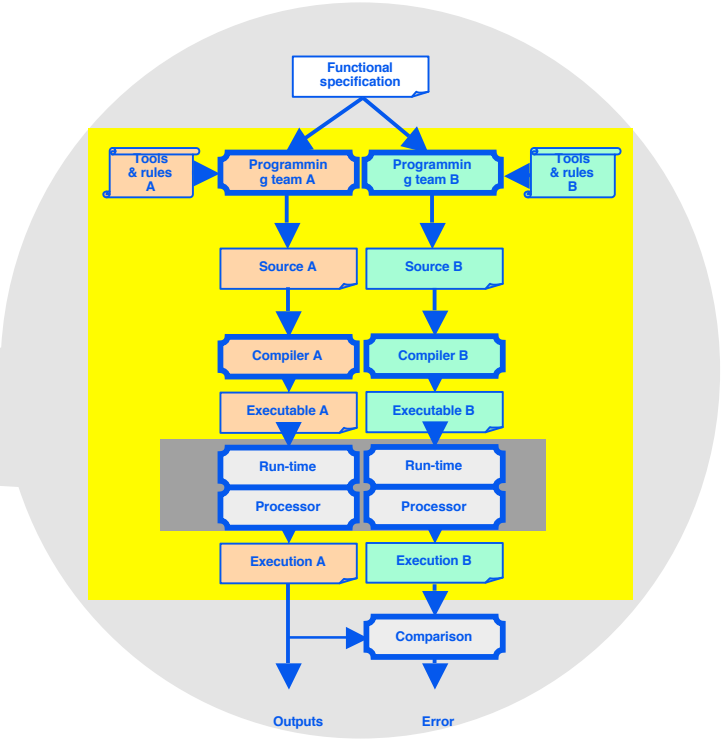
Elevator



Vertical rudder

FAC1

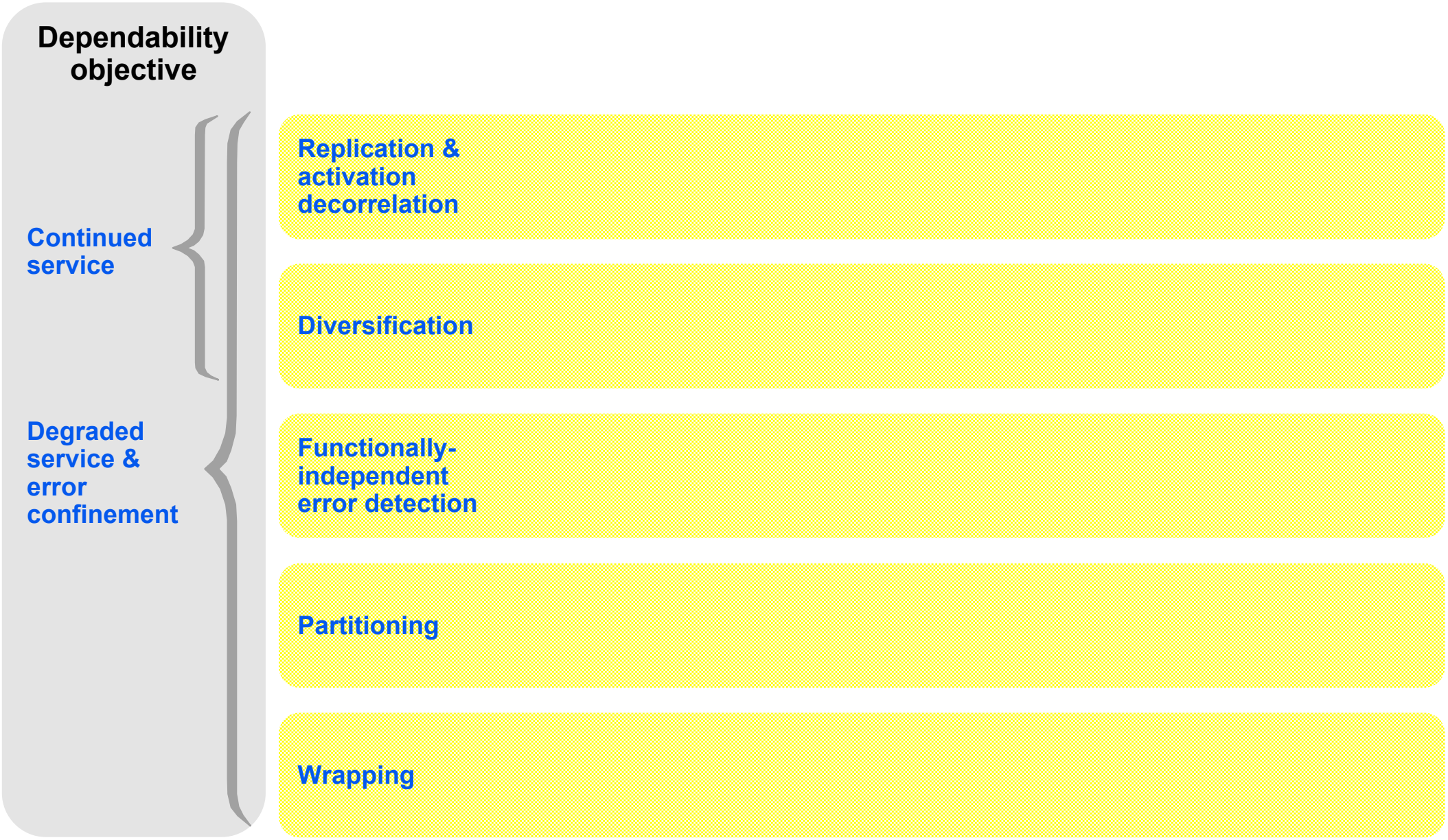
FAC2



Spoiler and Elevator Computer
SFENA/Aerospatiale
80186

ELevator and Aileron Computer
Thomson CSF
68010

Summary


Dependability objective
Continued service
Degraded service & error confinement
Replication & activation decorrelation
Diversification
Functionally-independent error detection
Partitioning
Wrapping

Summary

Dependability objective	Type of COTS	Hardware	Executive or *Middleware*	Compiler	Application
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	Diversification				
Degraded service & error confinement	Functionally-independent error detection				
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	Wrapping				

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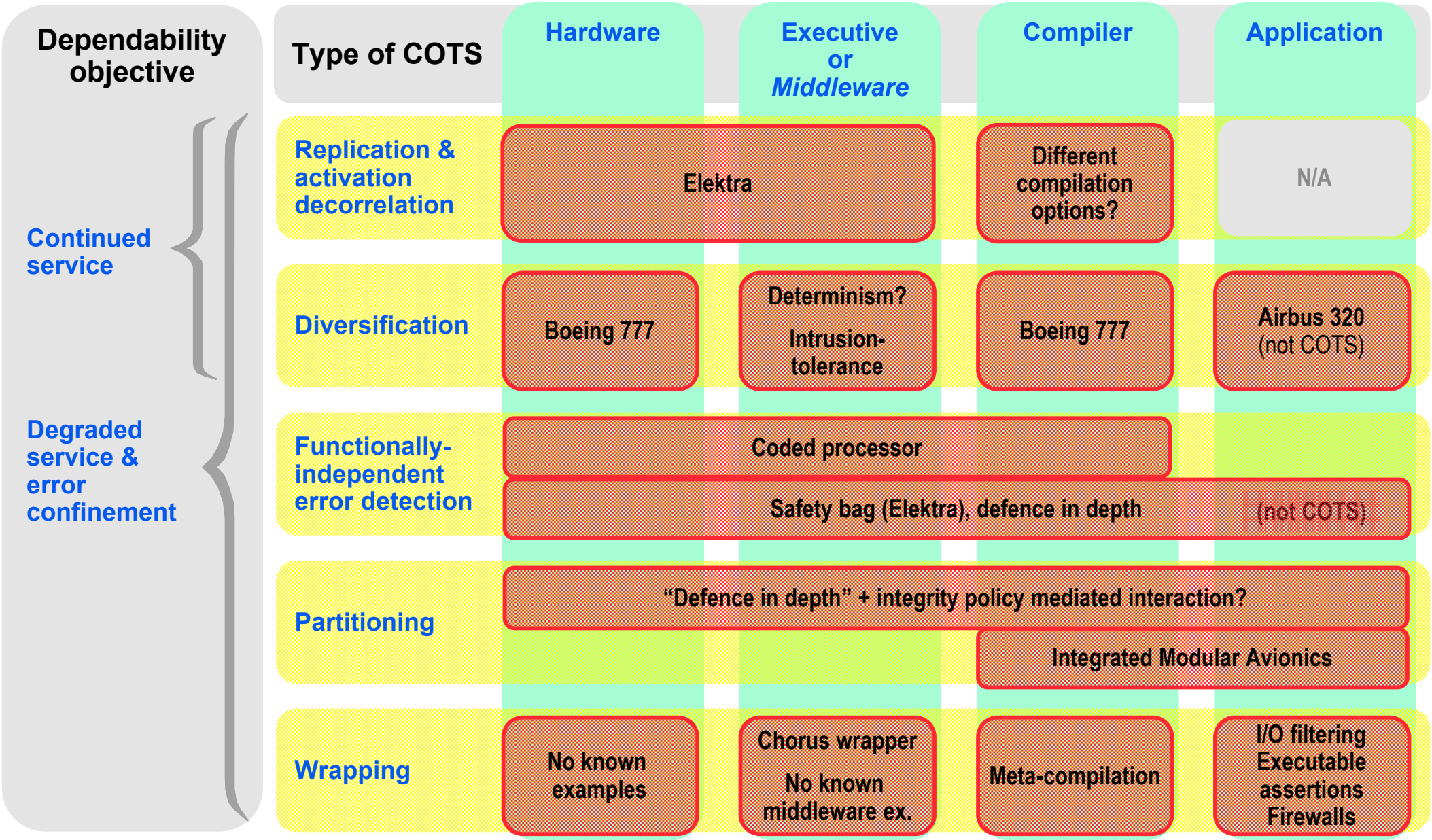
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Hardware
Executive or Middleware
Compiler
Application
Continued service
Degraded service & error confinement
Replication & activation decorrelation
Elektra
Different compilation options?
N/A
Diversification
Boeing 777
Determinism?
Intrusion-tolerance
Boeing 777
Airbus 320 (not COTS)
Functionally-independent error detection
Coded processor
Safety bag (Elektra), defence in depth
(not COTS)
Partitioning
"Defence in depth" + integrity policy mediated interaction?
Integrated Modular Avionics
Wrapping
No known examples
Chorus wrapper
No known middleware ex.
Meta-compilation
I/O filtering
Executable assertions
Firewalls

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