Cyber Resiliency and Survivability in Aerospace & Defense Domains

2023 IFIP WG10.4 Workshop Panel
“Dependability and Security Challenges in the face of 21st Century Threats and Trends: Industry and Academic Perspectives”

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Fault Classification*

Fault Classes addressed in 20th Century

NATURE		ORIGIN						PERSISTENCE		Usual Labelling
		Phenomenological Cause		System Boundaries		Phase of Creation				
Accidental Faults	Intentional Faults	Physical Faults	Human-made Faults	Internal Faults	External Faults	Design Faults	Operational Faults	Permanent Faults	Temporary Faults	
X		X		X			X	X		*Physical Faults*
X		X			X		X	X		
X		X			X		X		X	*Transient Faults*
X		X		X			X		X	*Intermittent Faults*
X			X	X		X			X	
X			X	X		X		X		*Design Faults*
X			X		X		X		X	*Interaction Faults*
	X		X	X		X		X		*Malicious Logic*
	X		X	X		X			X	
	X		X		X		X	X		*Intrusions*
	X		X		X		X		X	

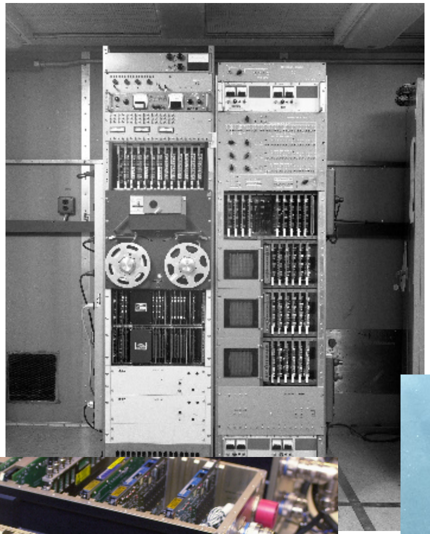
* J. C. Laprie (ed), "Dependability: Concepts & Terminology," Dependable Computing and Fault-Tolerant Systems, Vol. 5, Figure 3, Springer-Verlag, Wien-New York, 1992.

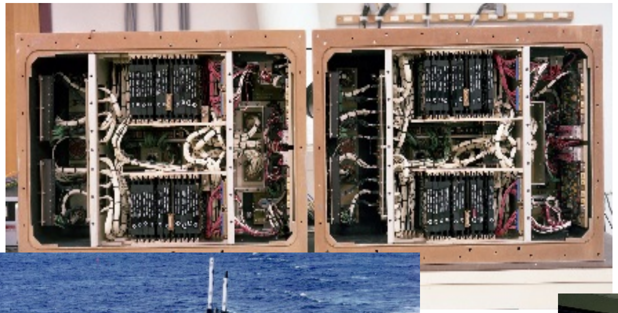
20th Century Progress in Dependable Systems

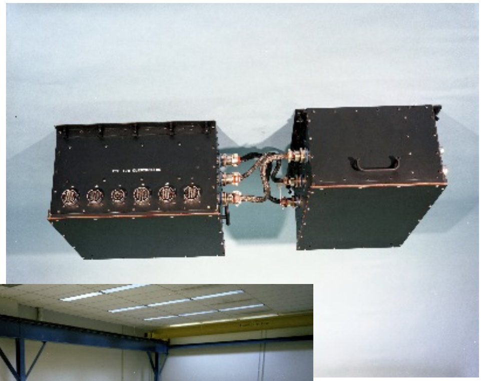
- As the use of digital systems (hardware, software, and networks) proliferated, their many shortcomings created impediments in applications demanding high dependability.
- Long-term efforts by the community (academia, industry, and governing bodies), resulted in remarkable progress in tackling 3 pillars of dependability (specifications, designs, and V&V).
- Systems that can tolerate accidental faults have been successfully deployed in all walks of life and at huge scales and at extremely high levels of dependability:
  - Air and space travel
  - Communications
  - Defense
  - e-commerce
  - Finance
  - Ground transportation
  - Industrial production

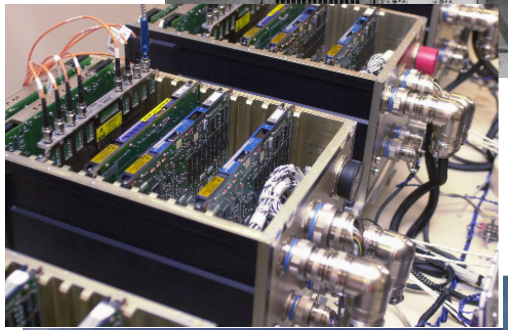
Digital fabric of society is highly reliable, available, and safe.

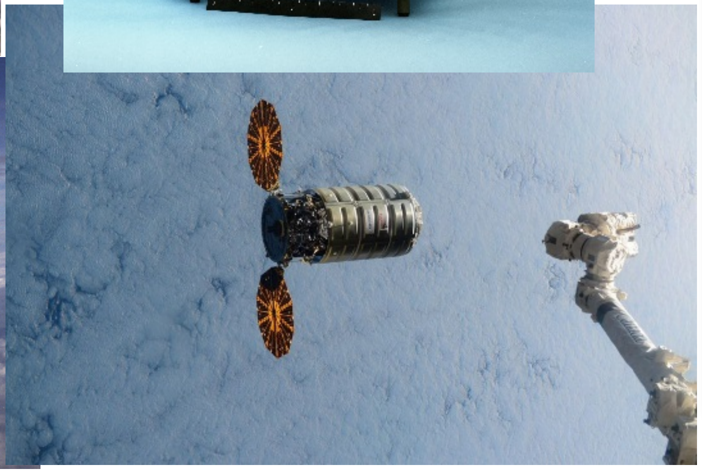
Example Safety-Critical Computers (Draper Lab)











- Numerous mission and safety-critical fault tolerant computers
- Space, Air, Ground, and Sea Platforms
- Triple, Quad or Higher Redundancy
- Theoretically Correct FT Architectures
- Fault-Tolerant Software
- Extensive Analytical & Empirical Validation

Turn of the Century: Change in Threat Landscape

- At the end of 20th century, having done enough damage for a quarter century at Draper, I was ready to retire from the dependable field.

- Then something happened that gave me job security ☺

Hackers Testifying at the United States Senate, May 19, 1998 (L0pht Heavy Industries)

https://www.youtube.com/watch?v=VVJldn_MmMY

Intrusion Tolerant Systems
Fault Classification & ITS Scope

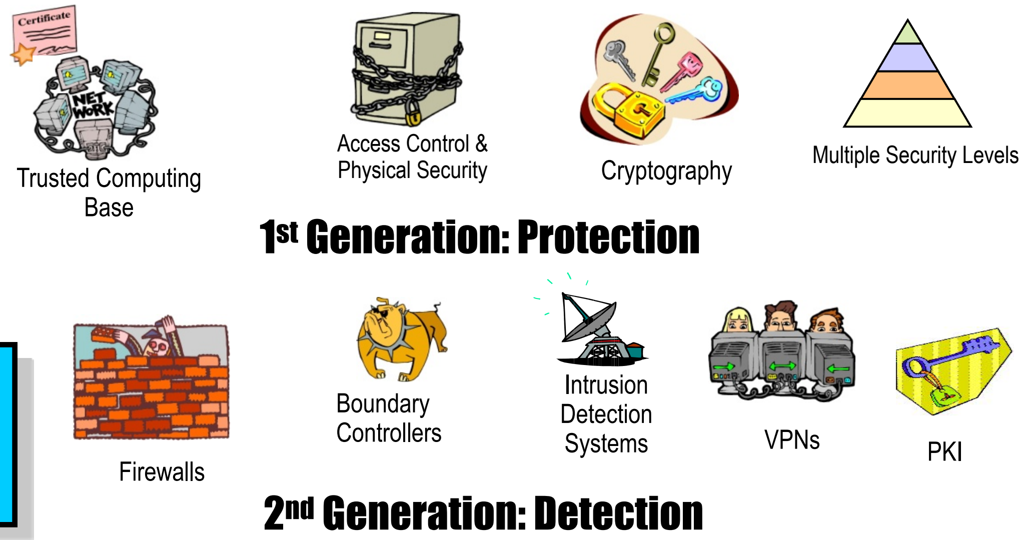
	NATURE		ORIGIN						PERSISTENCE		Usual Labelling
			Phenomenological Cause		System Boundaries		Phase of Creation				
	Accidental Faults	Intentional Faults	Physical Faults	Human-made Faults	Internal Faults	External Faults	Design Faults	Operational Faults	Permanent Faults	Temporary Faults	
Fault Tolerance	X		X		X			X	X		Physical Faults
	X		X			X		X	X		
	X		X			X		X		X	Transient Faults
	X		X		X			X		X	Intermittent Faults
	X			X	X		X			X	
	X			X	X		X		X		Design Faults
	X			X		X		X		X	Interaction Faults
ITS		X		X	X		X		X		Malicious Logic
		X		X	X		X			X	
		X		X		X		X	X		Intrusions
		X		X		X		X		X	

Cyber Resilient Architectures

Prevent Intrusions
(Access Controls, Cryptography, Trusted Computing Base)

But intrusions will occur

Detect Intrusions, Limit Damage
(Firewalls, Intrusion Detection Systems, Virtual Private Networks, PKI)



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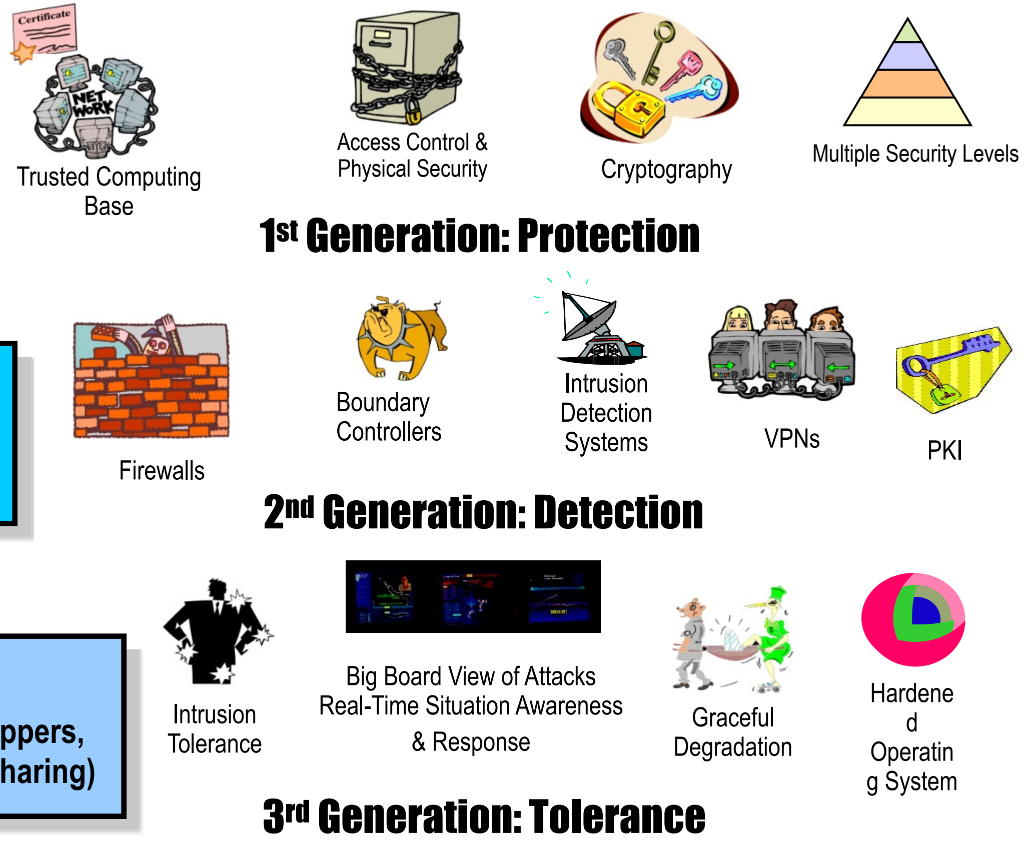
Tolerate Attacks
(Redundancy, Diversity, Deception, Wrappers, Proof-Carrying Code, Proactive Secret Sharing)



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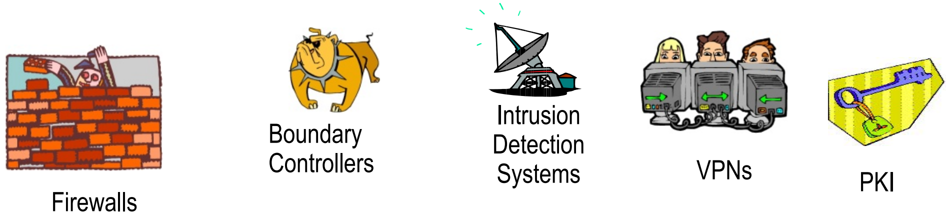
So the system must reconstitute

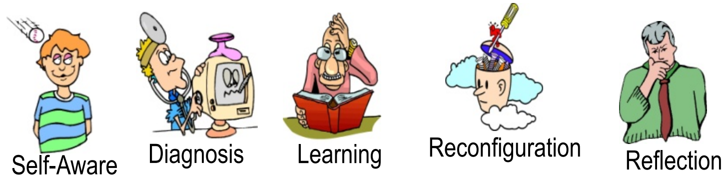
Restore System
(Diagnosis, Learning, Reconfiguration, S/W Rejuvenation, Natural Immunity, Reflection)

1st Generation: Protection



2nd Generation: Detection

3rd Generation: Tolerance



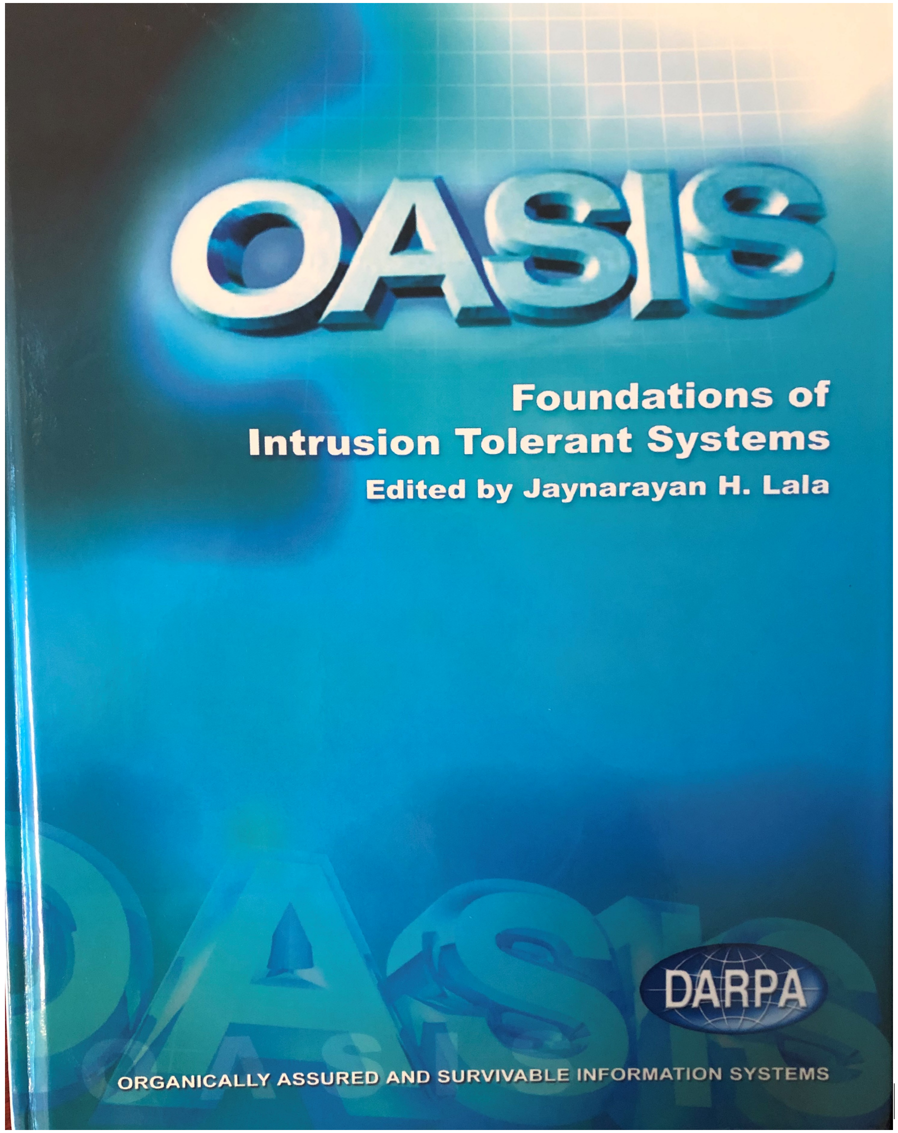
4th Generation: Regeneration

From Fault-Tolerance to Cyber Survivability

OASIS

Self- Regenerative Systems

Operate Through Attacks!!



US Dept of Defense Policy: Cyber Survivability

- Programs will employ system security engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability in design, test, manufacture, and sustainment.

- Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

DoD Instruction 5000.83

Technology and Program Protection to Maintain Technological Advantage

Originating Component:	Office of the Under Secretary of Defense for Research and Engineering
Effective:	July 20, 2020
Change 1 Effective:	May 21, 2021
Releasability:	Cleared for public release. Available on the Directives Division Website at https://www.esd.whs.mil/DD/.
Incorporates and Cancels:	See Paragraph 1.3.
Approved by:	Michael D. Griffin, Under Secretary of Defense for Research and Engineering
Change 1 Approved by:	Barbara K. McQuiston, Performing the Duties of the Under Secretary of Defense for Research and Engineering

Purpose: In accordance with the authority in DoD Directive (DoDD) 5137.02, the policy in Section 133a of Title 10, United States Code, and Directive-type Memorandum S-DTM-19-005, this issuance:

- Establishes policy, assigns responsibilities, and provides procedures for science and technology (S&T) managers and engineers to manage system security and cybersecurity technical risks from foreign intelligence collection; hardware, software, cyber, and cyberspace vulnerabilities; supply chain exploitation; and reverse engineering to:
  - DoD-sponsored research and technology that is in the interest of national security.
  - DoD warfighting capabilities.
- Assigns responsibilities and provides procedures for S&T managers and lead systems engineers for technology area protection plans (TAPPs), S&T protection, program protection plans (PPPs), and engineering cybersecurity activities.

Cyber Survivability is now a Key Performance Parameter (KPP): Must meet requirement