

Advanced Memory Study Use Cases and Requirements

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Objective

- Survey NASA and USAF projects to gather system-level memory requirements / desirements.
 - Near-term (1 - 5 years)
 - Medium-term (5-10 years)
 - Long-term (10-15 years)

Use-Case Approach

- Multi-Organization team surveying projects in their mission area.

Multi-Organization Team

NASA-SMD:

Dan Nakamura (JPL)

Karl Strauss (JPL)

Robert Stone (GSFC)

Alan Leung (GSFC)

Rebekah Austin (GSFC)



NASA-HEOMD:

Hester Yim (JSC)



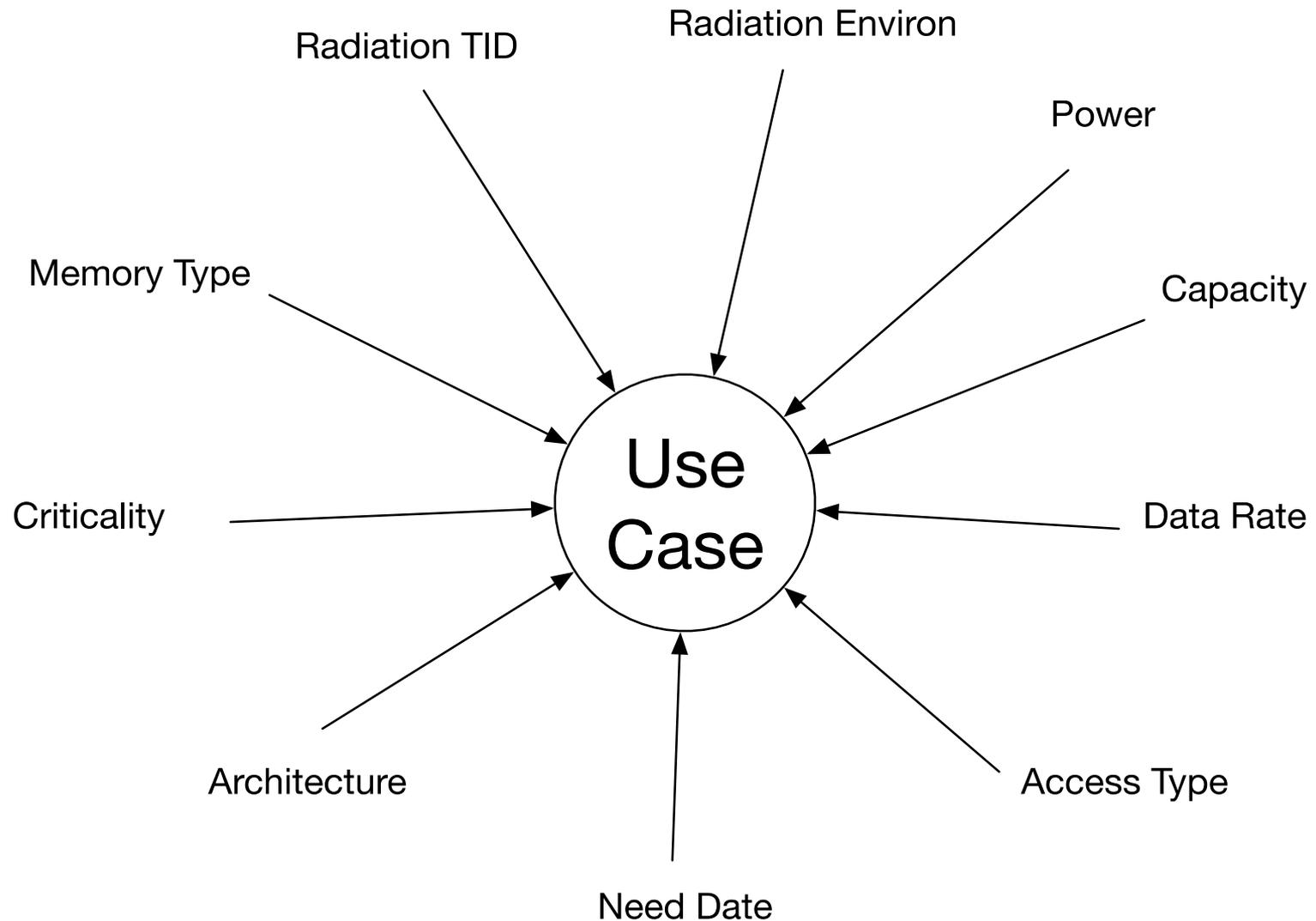
USAF:

Richard Marquez (AFRL)

Jesse Mee (AFRL)



Use-Case Parameters



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Parameter Priority

- Result of participants ranking memory parameters by importance
 - 1st Place: Radiation
 - 2nd Place: Capacity
 - 3rd Place: Data Rate

Use Case Views

- Sort the data to extract trends
 - By Organization
 - By Meta Application
 - By Volatile vs Non-Volatile

By Organization Summary

- Most Aggressive Requirement Leaders:
 - Radiation: USAF
 - Capacity: NASA-SMD
 - Data Rate: NASA-SMD

By Meta Application

- Meta = synthetic use case encompassing the needs from multiple similar projects.
- Reason: Simplify
 - 9 meta applications covers 40 potential use cases

1. Autonomous GNC	5. Model Based Autonomy	8. Missions
a. Extreme Terrain Landing	a. Advanced Vehicle Health Management	a. Europa/Icy Moons
b. ALHAT/Next Gen ALHAT	b. Human Movement Assist	b. Origins, Spectral Interpretation, Resource Identification, and Security -Regolith Explore
c. Terrain Relative Nav/Hazard Avoidance	c. Disaster Response Constellation	c. Next Mars Orbiter
d. Efficient On-orbit Satellite Maneuver	d. Science Event Detection	d. Orion Command & Data Handling
e. Lander Vision System	e. Mission Planning (Real Time)	MARS ROVERS [Planetary Science]
2. Displays and Controls	6. Surface Mobility	e. MER [Spirit/Opportunity]
a. Software GPU	a. New Surface Mobility Methods	f. MSL [Curiosity]
b. Improved Displays and Controls	b. Fast Traverse	g. Mars 2020 [Rover]
c. Augmented Reality for Recognition and Cataloguing	7. Instruments	TELESCOPES [Astrophysics]
d. Immersive Environments for Science Ops/Outreach	a. Science RADAR (Next Gen)	h. Hubble Space Telescope
3. Mass Store	b. NASA-ISRO Synthetic Aperture Radar	i. Servicing Mission 1
a. Solid State Recorder	c. Hyperspectral Imaging	ii. Servicing Mission 2
b. Cloud Services	d. Space Based Infrared System	iii. Servicing Mission 3A
c. Crew Knowledge Augmentation	e. Gamma Ray Imager	iv. Servicing Mission 4
4. Delay Tolerant Network		i. James Webb Space Telescope
a. Laser Communication Relay Demonstration		j. Wide Field InfraRed Survey Telescope
b. Plankton, Aerosol, Cloud, ocean Ecosystem		9. CubeSat
		a. Planetary Missions
		b. Lunar Flashlight
		c. NEAScout

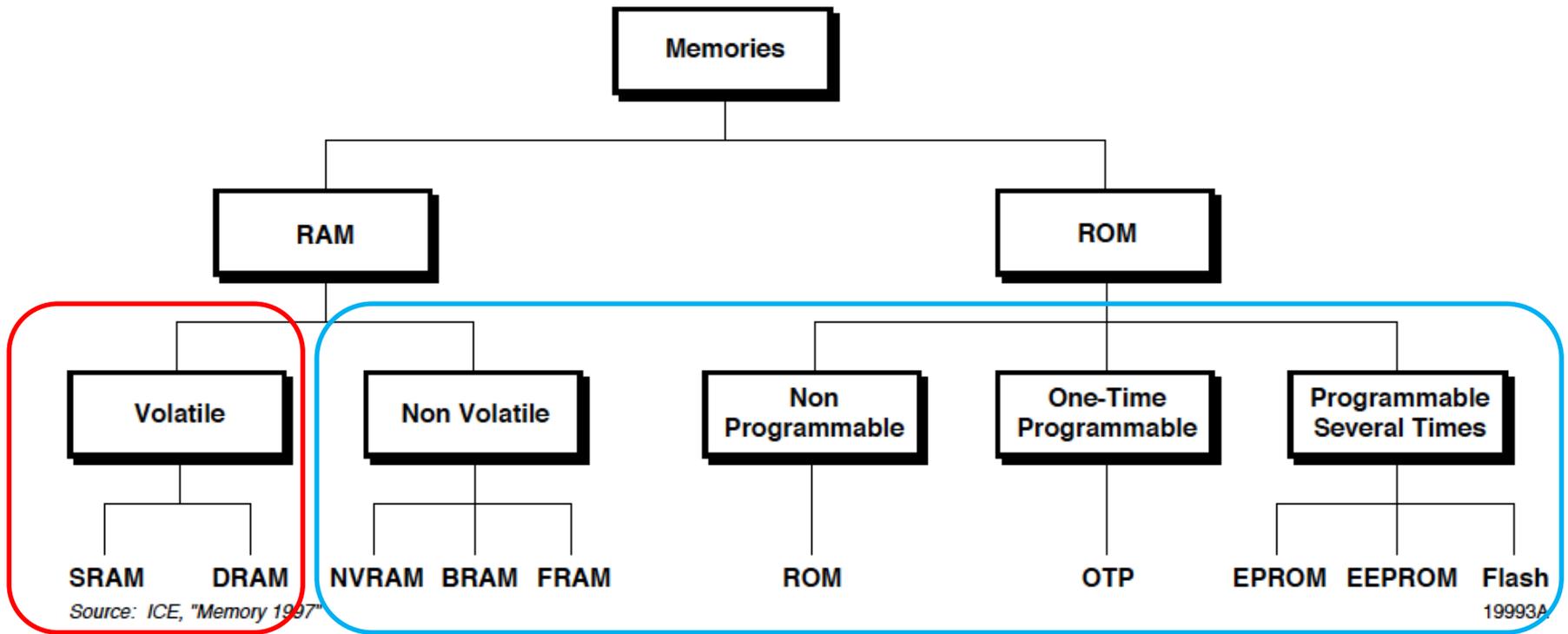
Predecisional information for planning and discussion only

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Meta Application Summary

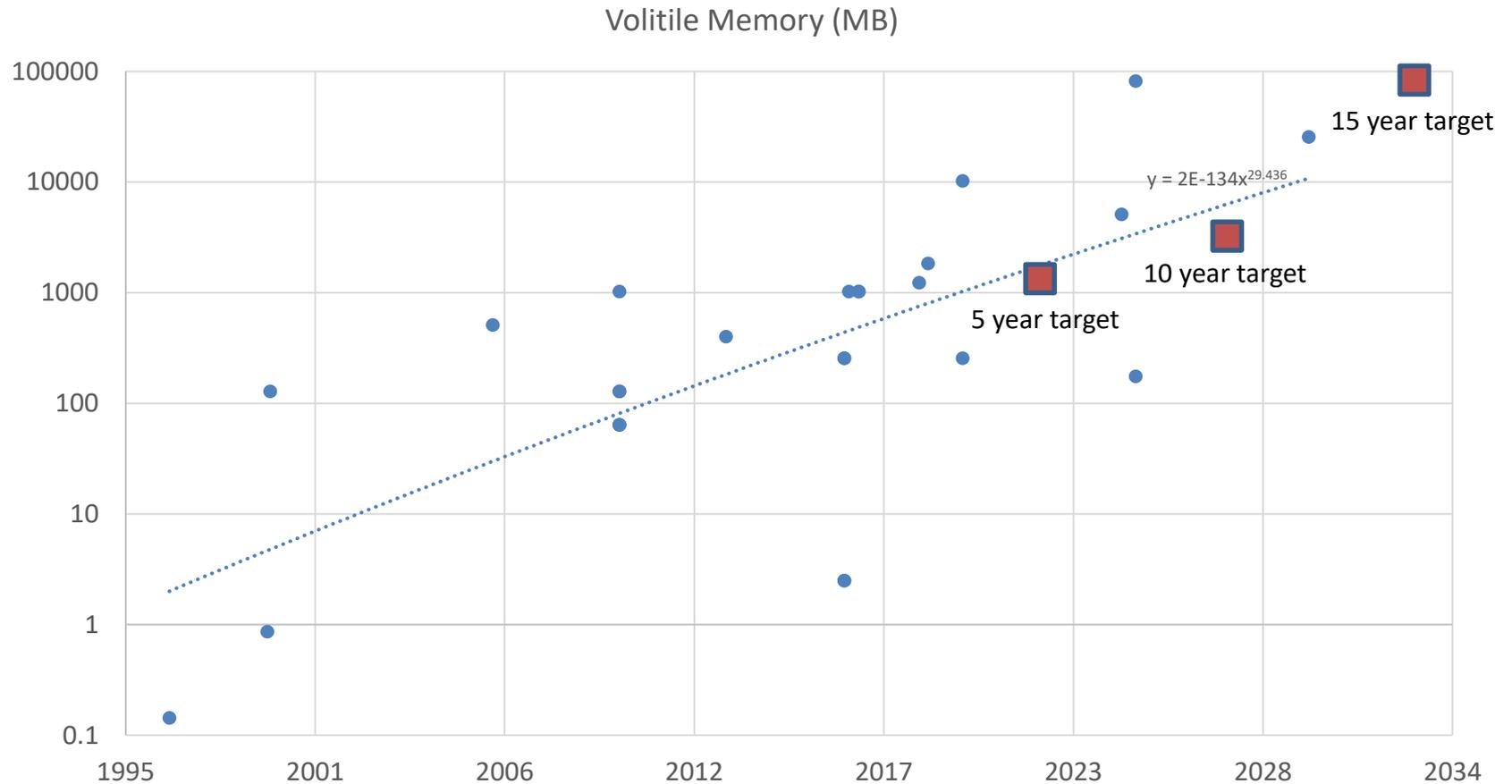
- **1st Place: Instruments**
 - Driving data volume
- **2nd Place: Mass Store**
 - Need to store instrument data because of limited downlink bandwidth.

By Volatile Vs Non-Volatile



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Volatile Memory Needs



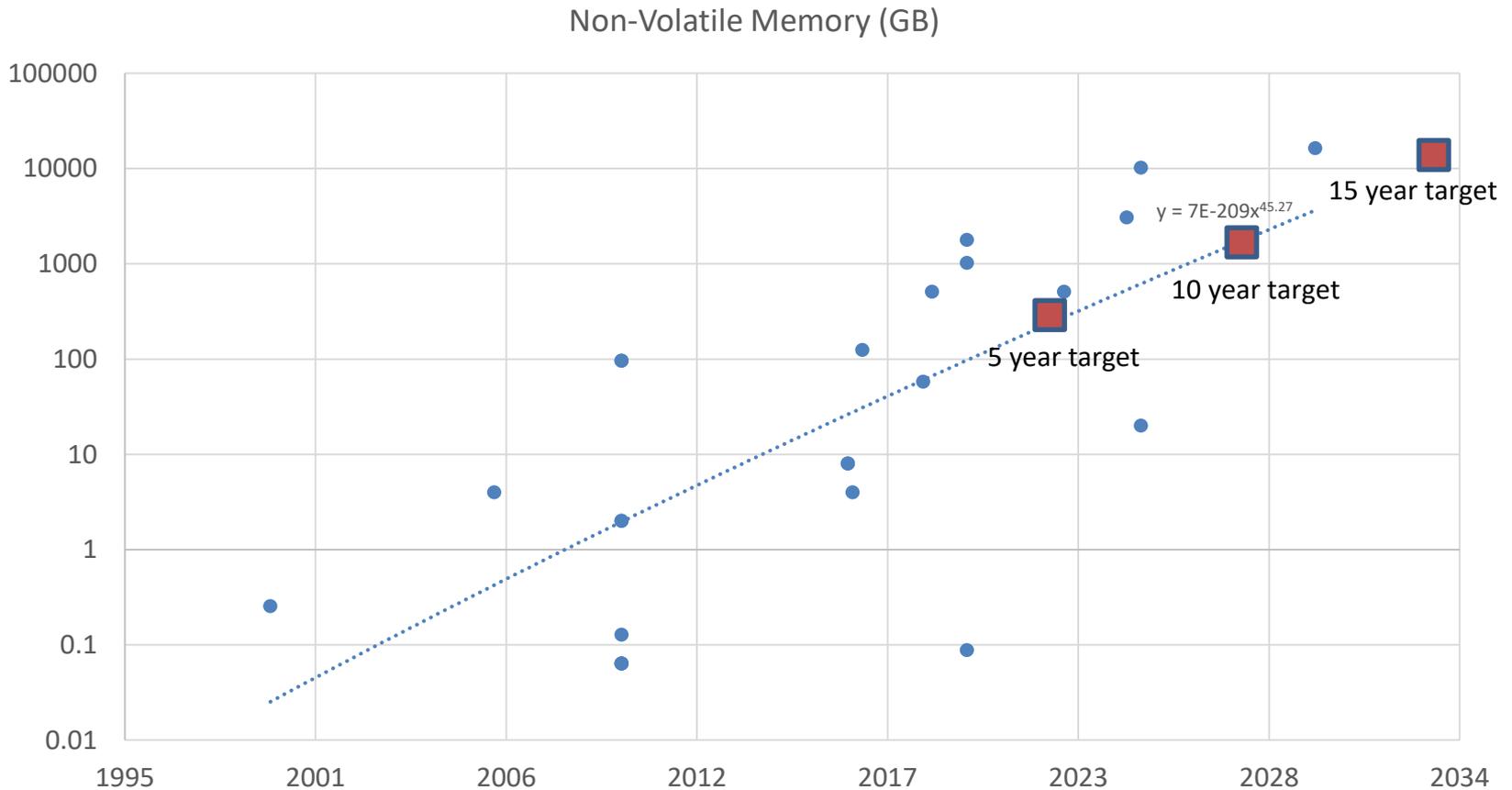
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Volatile Needs Summary

- Volatile Capacity Needs
 - 5 year Target: 1.2 GB
 - 10 year Target: 5 GB
 - 15 year Target: 100 GB

Non-Volatile Memory Needs



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Non-Volatile Needs Summary

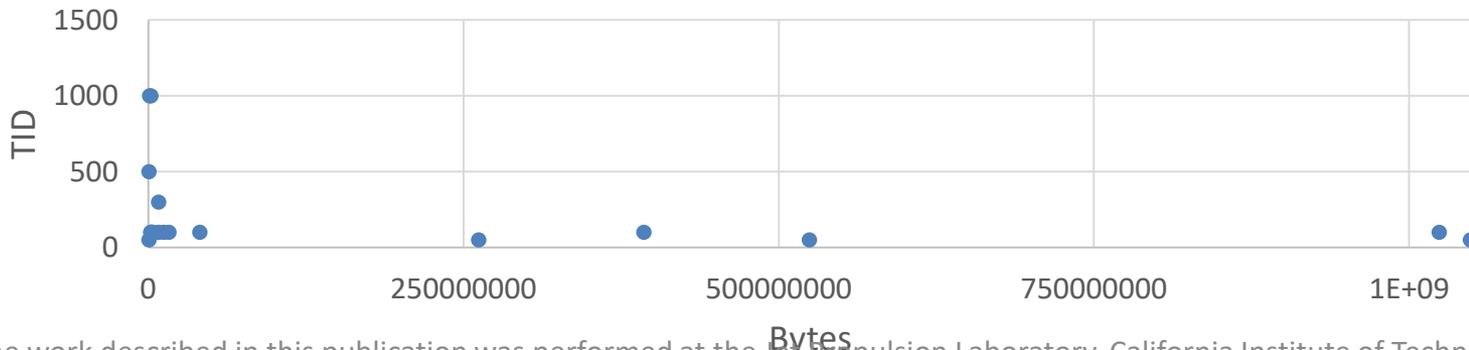
- Non-Volatile Capacity Needs
 - 5 year Target: 512 GB
 - 10 year Target: 3 TB
 - 15 year Target: 20 TB

Volatile Memory Available Today

- Largest Capacity: 1G x 8 @ 100 krad
 - Today (1 GB): 1x, Usable
 - Future (100 GB): 100x, not SWaP

Manufacturer	Memory	Part Number	Config	Total Bytes	TID (krad)	SEU	Package
BAE	SRAM	251A172	512kx32	2097152	100	1.00E-10	
BAE	SRAM	251A137	512kx40	2621440	100	1.00E-10	
BAE	SRAM	8394325	512kx8	524288	500	1.00E-10	
BAE	SRAM	8464575	2Mx32	8192000	100	1.00E-11	
BAE	SDRAM	8515862	128Mx16	262144000	50	1.00E-09	
BAE	SSRAM	8497642	128kx72	1179648	1000	1.00E-10	
BAE	SRAM	8485896	8Mx40	40960000	100		
Aeroflex	SSRAM	UT8SP2M48	2Mx48	12288000	100	1.70E-06	288 CLGA/CBGA
Aeroflex	SRAM w/EDAC	UT8ER512K32	512kx32	2097152	100	8.00E-16	68 FP
Aeroflex	SRAM	UT8Q512E	512kx8	524288	50	1.10E-09	36 FP
Aeroflex	SDRAM	UT8SDMQ64M48	64Mx48	393216000	100	1.30E-10	128 FP
Aeroflex	SRAM	UT8ER4M32	4Mx32	16384000	100	8.00E-16	132 FP
Honeywell	SRAM	HXSR06432	2Mx32	8192000	300	2.00E-12	86 CFP
Honeywell	SRAM	HLXSR0108	2Mx8	2048000	1000	5.00E-12	40 CFP
Atmel	SRAM	AT60142H	512kx8	524288			
3Dplus	SRAM	3DSR32M32V58501	1Mx32	4096000	100	6.00E-08	SOP68
3Dplus	SDRAM	3DS4D4G08VS8613	512Mx8	524288000	50	2.00E-10	SOP58
3Dplus	DDR SDRAM	3D1D8G16TS8466	512Mx16	1048576000	50	1.00E-09	SOP78
3Dplus	DDR2 SDRAM	3D2D8G08US8663	1Gx8	1024000000	100	5.00E-11	SOP88

Volatile Memory Chips - RadHard



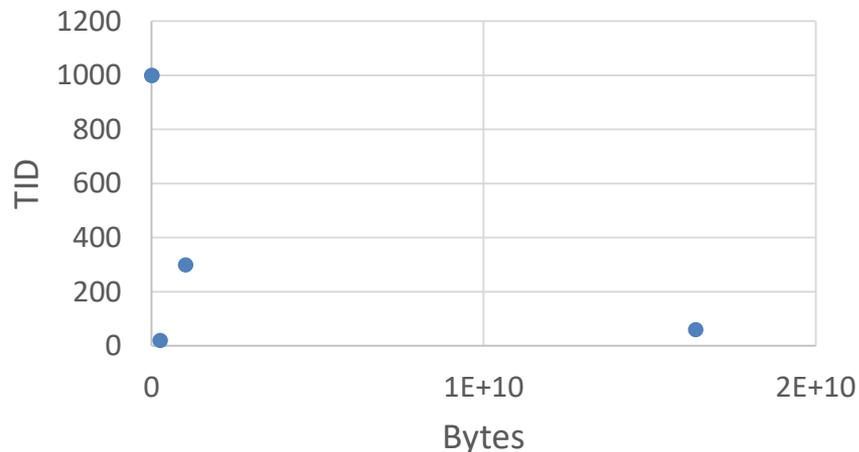
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Non-Volatile Memory Available Today

- Largest Capacity: 16G x 8 @ 60 krad
 - Today (512 GB): 32x, Pushing SWaP limit
 - Future (20 TB): >1000x, Cannot meet SWaP

Manufacturer	Memory	Part Number	Config	Total Bytes	TID (krad)	SEU	Package
3Dplus	FLASH NOR	3DF02G08VS4215	256Mx8	262144000	20	1.00E-11	SOP60
3Dplus	FLASH NAND	3DFN128G08VS8308	16Gx8	16384000000	60	2.00E-10	SOP50
Samsung	FLASH NAND	K9F8G08U0M	1Gx8	1024000000	300		52ULGA
Honeywell	MRAM	HXNV06400 Quad	4Mx16	8192000	1000	1.00E-10	112LCFP
Aeroflex	MRAM	UT8MR8M8	8Mx8	8192000	1000	Immune	64LCFP

Non-Volatile Memory Chips - RadHard



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Conclusion

- **Need Rad-Hard memory manufacturer's help to meet future memory needs.**
- **Volatile Memory Req (15 year System-Level)**
 - Radiation: 83 – 500 kRad
 - Capacity: 91 – 100 GB
 - Data Rate: 37 Gbps – 1 Tbps
- **Non-Volatile Memory Req (15 year System-Level)**
 - Radiation: 75 – 500 kRad
 - Capacity: 13 – 20 TB
 - Data Rate: 50 – 56 Gbps