Environmental DeRating as a Cost Driver

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presented to the
PRICE Users Symposium
Philadelphia, October 22,1998

Environmental DeRating as a Cost Driver

Presentation Outline

- **Introduction and Overview**
  - Overview, Purpose, Goals, Study Methodology
- **Manufacturing Complexity Param Development**
- **Vehicle Operating Speed versus Specm**
- **Environmental Derating Factor versus Specm**
- **Summary**
  - Conclusions and Recommendations
  - Author Biographies

Environmental DeRating as a Cost Driver

Abstract

- One of the most significant cost drivers of any system is the environment in which the system will be operated. Today’s cost models are generally based on a discrete environment model. Using a discrete model to describe something as continuous as environment will not guarantee adequate sensitivity. To increase cost model sensitivity for systems operating in different environments, a sub-model has been developed to describe and measure cost effects using reliability environmental de-rating factors as a basis for calculations.

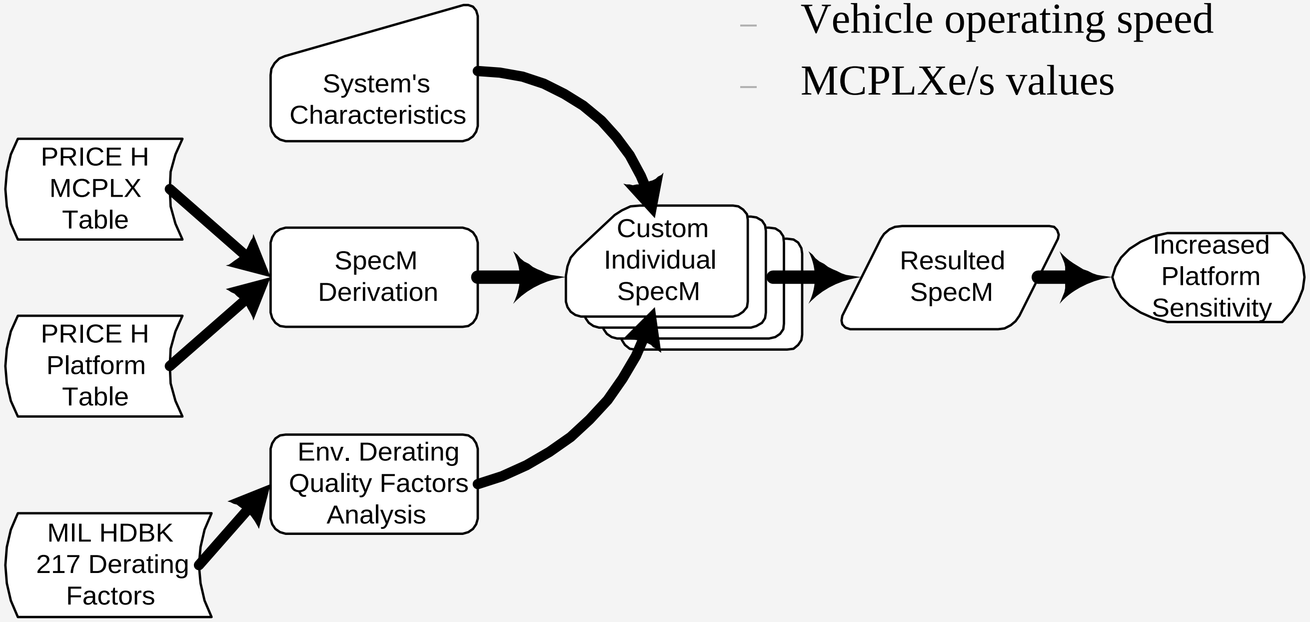
- In this paper, the environmental de-rating factors from MIL-HDBK-217 D are correlated to the platform values used in the PRICE Systems Hardware cost model to derive a more sensitive platform table. An example is the dissection of the military airborne platform into values for trainers, fighters, attack, bombers, and transports.

Purpose and Objectives

- **Develop Param algorithm**
  - Provide continuous function generator for MCPLXe/s
  - Calibrate new Platform ‘Specm’ values
  - Normalize thousands of MCPLXe/s values to any Platform value
- **Increase understanding of Platform**
  - Higher fidelity
  - Add drivers
    - Environmental de-rating factors
    - Operating speed
  - Extrapolate beyond Platform 2.5
- **Study scope excludes the effects of business culture and reliability/maintainability upon Platform**

Study Methodology

- **Develop interrelationships between**
  - the PRICE Platform table
  - Mil-Hdbk-217 de-rating factors
  - Vehicle operating speed
  - MCPLXe/s values



PRICE-H Platform and MCPLXs Values

Platform= The operating environment of the equipment

MCPLXe = Manufacturing Complexity of electronics

Typical Price H PLTFM Value

Operating Environment	PLTFM Value
Ground	
Benign	0.6
Commercial	0.8
High Grade Commercial	0.9
MIL Spec	1.0
Mobile	
Commercial	1.2
MIL Spec	1.4
Airborne	
Commercial	1.7
MIL Spec	1.8
Space	
Unmanned	2.0
Manned	2.5

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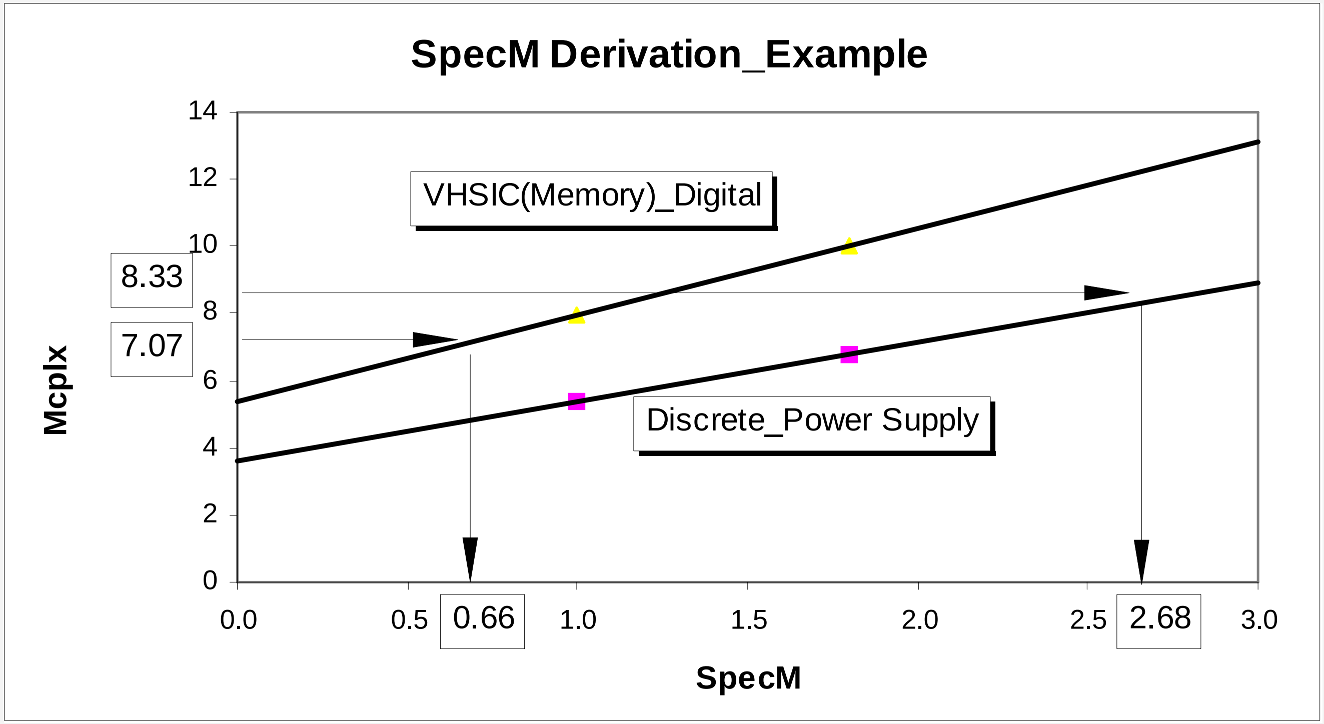
Price H Mx @1.8 plfm

	0.6	0.8	1.0	1.4	1.7	1.8	2.0	2.5	slope
DISCRETES									
Analog, Audio	5.58	5.91	6.26	7.02	7.66	7.88	9.08	9.67	2.03
Analog, RF/Video	5.68	6.01	6.37	7.15	7.79	8.02	9.24	9.84	2.06
Digital	5.37	5.69	6.03	6.77	7.38	7.59	8.75	9.32	1.95
Display	5.28	5.59	5.92	6.64	7.24	7.45	8.59	9.15	1.92
No-CRT	5.17	5.48	5.80	6.51	7.10	7.30	8.41	8.96	1.88
Transmitter	5.77	6.11	6.47	7.26	7.92	8.15	9.38	10.00	2.10
Power Supply	4.80	5.09	5.39	6.05	6.59	6.79	7.82	8.33	1.75
SSIC									
Analog, Audio	5.71	6.05	6.41	7.19	7.84	8.07	9.30	9.90	2.08
Analog, RF/Video	5.83	6.17	6.54	7.34	8.00	8.24	9.49	10.11	2.12
Digital	5.51	5.83	6.18	6.93	7.56	7.78	8.96	9.55	2.00
Display	5.43	5.75	6.09	6.83	7.45	7.67	8.83	9.41	1.97
No-CRT	5.35	5.66	6.00	6.73	7.34	7.56	8.70	9.27	1.95
Transmitter	5.92	6.27	6.60	7.45	8.12	8.36	9.63	10.26	2.15
Power Supply	4.95	5.24	5.55	6.23	6.79	6.99	8.05	8.58	1.80
MSIC									
Analog, Audio	5.85	6.19	6.56	7.36	8.03	8.26	9.51	10.14	2.13
Analog, RF/Video	5.89	6.24	6.61	7.42	8.09	8.32	9.59	10.21	2.14
Digital	5.64	5.98	6.33	7.10	7.74	7.97	9.18	9.78	2.05
Display	5.55	5.88	6.23	6.99	7.62	7.84	9.04	9.63	2.02
No-CRT	5.47	5.80	6.14	6.89	7.51	7.73	8.91	9.49	1.99
Transmitter	5.98	6.33	6.71	7.53	8.21	8.45	9.73	10.37	2.17
Power Supply	5.00	5.30	5.61	6.30	6.86	7.06	8.14	8.67	1.82
LSI									
Analog, Audio	5.97	6.32	6.70	7.52	8.20	8.44	9.72	10.35	2.17
Analog, RF/Video	6.02	6.37	6.75	7.57	8.26	8.50	9.79	10.43	2.19
Digital	5.77	6.11	6.47	7.26	7.92	8.15	9.38	10.00	2.10
Display	5.71	6.05	6.41	7.19	7.84	8.07	9.30	9.90	2.08
No-CRT	5.61	5.95	6.30	7.07	7.71	7.93	9.14	9.73	2.04
Transmitter	6.10	6.47	6.85	7.69	8.38	8.63	9.94	10.58	2.22
Power Supply	5.06	5.36	5.68	6.37	6.95	7.15	8.24	8.78	1.84
VLSI									
Analog, Audio	6.26	6.64	7.03	7.89	8.60	8.85	10.20	10.86	2.28
Analog, RF/Video									
Digital	6.06	6.42	6.80	7.63	8.32	8.56	9.86	10.51	2.20
Display	6.00	6.35	6.73	7.55	8.23	8.47	9.76	10.40	2.18
No-CRT	5.92	6.27	6.64	7.45	8.12	8.36	9.63	10.26	2.15
Transmitter	6.31	6.68	7.08	7.94	8.66	8.92	10.27	10.94	2.30
Memory	6.12	6.49	6.87	7.71	8.40	8.65	9.96	10.62	2.23
VHSIC(Gate Array)									
Digital	7.26	7.69	8.15	9.15	9.97	10.26	11.82	12.59	2.64
Display	7.19	7.62	8.07	9.06	9.87	10.16	11.70	12.47	2.61
No-CRT	7.09	7.51	7.96	8.93	9.74	10.02	11.54	12.30	2.58
VHSIC (Memory)									
Digital	7.07	7.49	7.93	8.90	9.70	9.99	11.50	12.25	2.57
Display	7.00	7.41	7.85	8.81	9.60	9.88	11.39	12.13	2.54
No-CRT	6.92	7.33	7.77	8.72	9.51	9.78	11.27	12.01	2.52

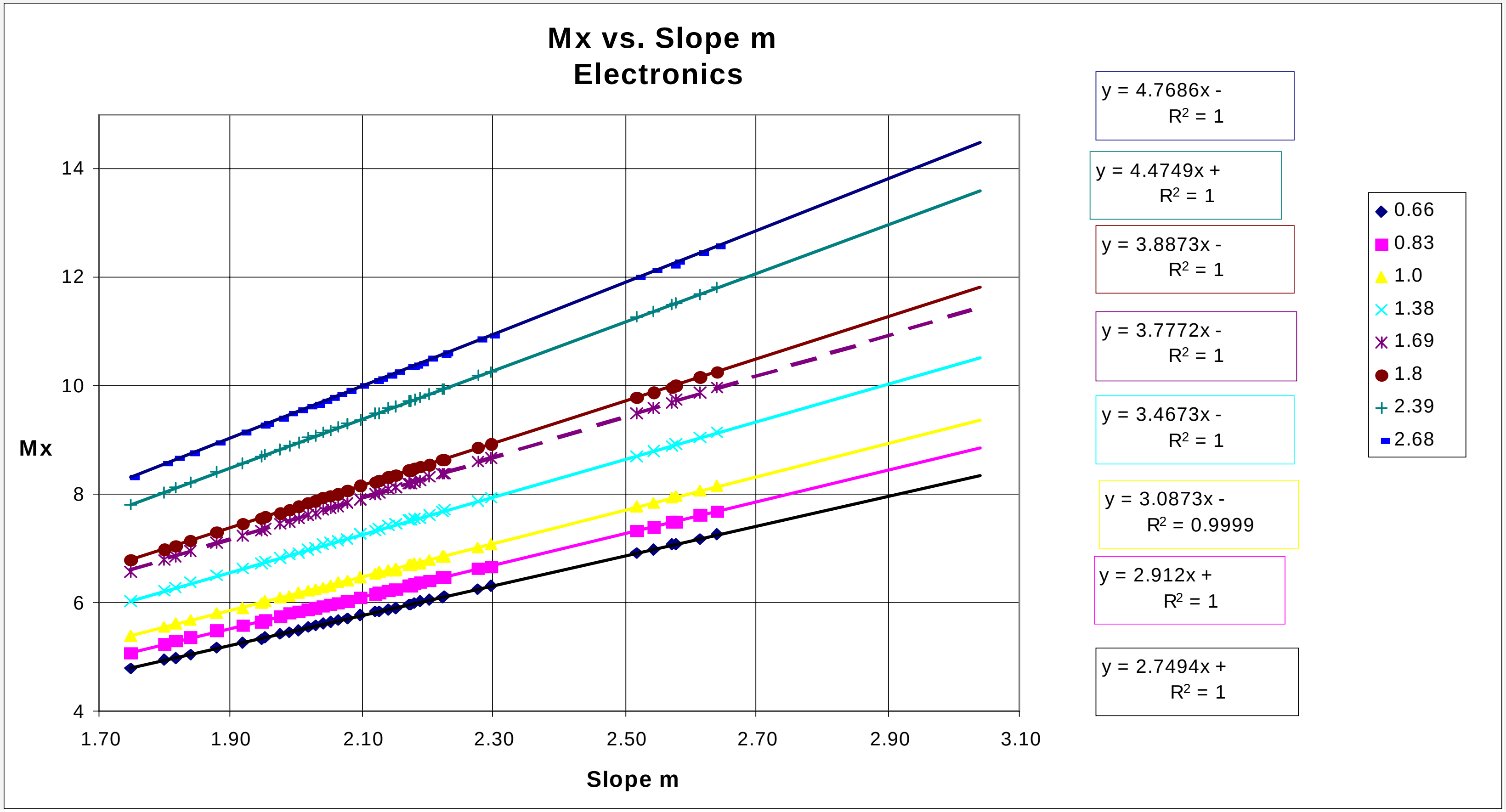
Baseline SPECm Derivation

- Plot MCPLXe values for Platforms 1.0 and 1.8 for each equipment type (x1,y1), (x2,y2)
- Perform linear regression on the two points for each equipment type MCPLXe=a(SPECm)+b
- Derive new SPECm values for each MCPLXe value from other Platforms



Param Algorithm Development

- Equation development and non-baseline SPECm value determination

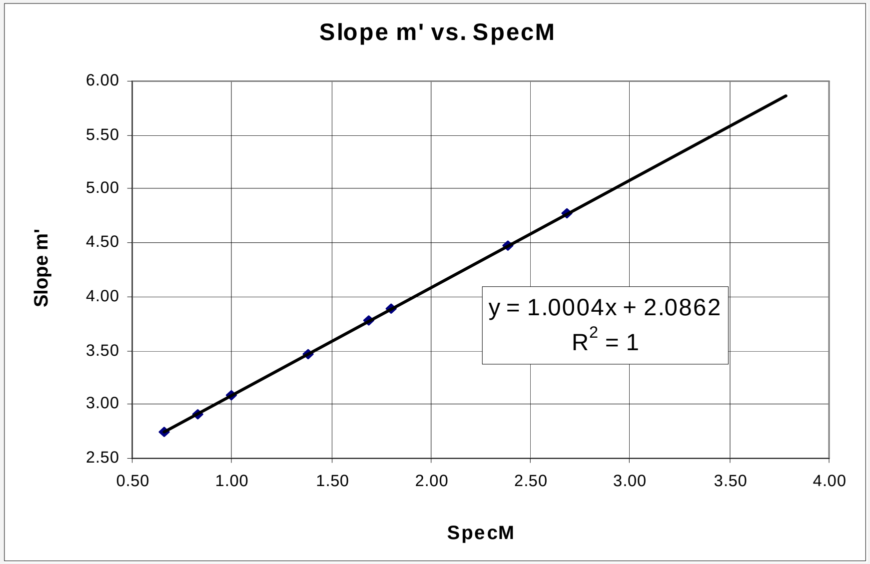


Manufacturing Complexity Param Development

- 1. Choose baseline platforms.
- (ex. MCPLXs=y1at Platform 1.0 and MCPLXs=y2 at Platform 1.8)
- 2. Plot MCPLXs values for baseline platforms.
- X1 to Y1 and X2 to Y2
- 3. Solve for linear solution; $Yi=aXi+b$ and $Xi=(Yi-b)/a$
- 4. For all other MCPLXs values, derive Platform values as a function of the linear solution. These Platform values are renamed SPECm for Manufacturing Specifications.
- 5. Take average of Xi (SPECm) values for corresponding MCPLXs values.
- 6. Redefine X axis as SPECm.
  - The values are similar to platform values
  - Allows simple smooth transition and mathematics between environmental levels
  - Platform values were originally multipliers on hours per drawing in development
  - Plotting MCPLXe/s values against platform values was incidental

Param Slope Analysis

- Higher manufacturing complexities sustain higher rate of increase as SPECm increases
- The rate of increase is consistent
- Slope coefficient modeling enables horizontal and vertical extrapolation possible



$$\textbf{Mcplx}_1 = (\textbf{Mcplx}_0 * m_0 + b_0) * (1.0004 * \textbf{SpecM}_1 + 2.0862)$$

Generated SPECm Table

SpecM Derivation

	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.6	0.8	1.0	1.4	1.7	1.8	2.0	2.5
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.69
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.69
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.82	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.37	1.69	1.80	2.39	2.68
	0.66	0.82	1.00	1.37	1.69	1.80	2.39	2.68
	0.67	0.83	0.98	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.69
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.69
	0.66	0.82	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.37	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.69
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.69
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.69
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.82	1.00	1.37	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.68
	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.69
Avg:	0.66	0.83	1.00	1.38	1.69	1.80	2.39	2.68
Min:	0.66	0.82	0.98	1.37	1.69	1.80	2.39	2.68
Max:	0.67	0.83	1.00	1.38	1.69	1.80	2.39	2.69

- Typical tolerance = +/- .01 SPECm
- Values correspond closely with Platform values
- PRICE tables consistent and empirical

Platform	SpecM
0.6	0.66
0.8	0.83
1.0	1.00
1.4	1.38
1.7	1.69
1.8	1.80
2.0	2.39
2.5	2.68

SPECm versus Speed

- Typical vehicle operating speeds correlate well with derived SPECm values
- SPECm can be derived for subsonic, supersonic and hypersonic vehicle speeds and associated equipment
- Note that speed requirements increase vibration, radiation, compaction, power and efficiency requirements

Regression: Speed vs Specm

TN-3100

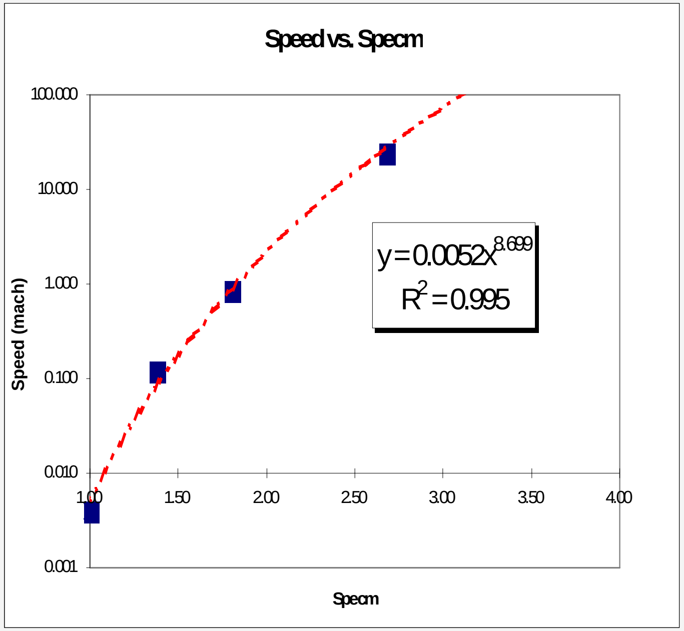
Guidelines: Manned, Reuseable

10/20/98

D329-300

Man Tended Specm	Specm	Speed (mach)	Data Used	Pred y	Error y	mph	
Grd Stationary	1.00	0.004	Yes	0.01	0.00	3	0.1012
Ground Mobile	1.38	0.12	Yes	0.08	-0.04	90	0.1012
Military Airborne	1.80	0.86	Yes	0.86	0.00	635	1.00
Manned Space (Orbit)	2.68	24.29	Yes	27.32	3.03	18,000	
	-	-	-	-	-		
	6.86	25.27	4	Power	0.77		

ALGORITHM FORM	X	Y	R^2	Form Select	Intercpt A	Slope B
Linear y=b*x+a	lin	lin	0.818	------	-19.45262	15.0269
Expon y=a*e^(bx)	lin	log	0.958	------	0.00007	4.9368
Power y=a*x^b	log	log	0.995	1	0.00515	8.6990
Logrth y=a+b*ln(x)	log	lin	0.695	------	-5.02666	23.9391



Composite DeRating Factor Development

	Environment		Code	De-Rating Factor (Df) IC	Hyb	Trns	Diode	Avg	Df Base	Base SPECm	Derieved SPECm
Ground	Stationary	Benign	G-B	1.1	1.1	0.8	0.4	0.9			0.81
		Fixed	G-F	7.2	4.2	3.9	2.3	4.4	**4.4**	**1.00**	**1.00**
Mobile	Mobile										1.42
		Manpack	M-P	10.9	10.7	9.5	10.4	10.4			1.32
		Mobile	G-M	12.0	11.8	14.3	10.8	12.2			1.42
	Naval	Submarine	N-SB	11.4	5.3	7.6	2.8	6.8			1.13
		Sheltered	N-S	11.4	9.1	7.6	3.5	7.9			1.19
		Hydrofoil	N-H	16.9	16.6	15.1	16.1	16.2			1.63
		Unsheltered	N-U	16.3	17.1	16.7	11.9	15.5			1.59
		Undersea-Unshelt	N-UU	18.0	18.2	15.9	17.2	17.3			1.69
Flight									**19.3**	**1.80**	**1.80**
	Cargo	Inhabited	A-IC	7.2	8.0	7.6	9.9	8.2	8.2		1.20
	Cargo	Uninhabited	A-UC	8.6	13.4	11.9	16.5	12.6	12.6		1.44
	Trainer	Inhabited	A-IT	8.6	8.0	11.9	13.2	10.4	10.4		1.32
	Trainer	Uninhabited	A-UT	11.4	13.4	19.9	19.8	16.1	16.1		1.63
	Attack	Inhabited	A-iA	11.4	10.7	15.7	16.5	13.6	13.6		1.49
	Attack	Uninhabited	A-UA	17.2	16.0	27.8	26.4	21.9	21.9		1.94
	Bomber	Inhabited	A-IB	14.3	13.4	27.8	20.9	19.1	19.1		1.79
	Bomber	Uninhabited	A-UB	21.5	21.4	47.7	34.1	31.2	31.2		2.44
	Fighter	Inhabited	A-IF	17.2	16.0	31.8	23.1	22.0	22.0		1.94
	Fighter	Uninhabited	A-UF	25.8	21.4	51.7	35.2	33.5	33.5		2.56
	Rotary Wing		A-RW	24.3	24.1	21.5	26.1	24.0	24.0		2.05
Launch	Missile	Nonpowered	M-FF	11.2	11.2	9.5	10.6	10.6			1.33
	Missile	Airbreathing	M-FA	15.5	15.5	13.5	14.8	14.8			1.56
	Space	(Benign)	S-F	2.6	1.7	0.6	0.4	1.3			0.84
	Undersea		L-US	31.5	32.6	28.6	32.2	31.2			2.44
	Missile		L-M	37.2	37.4	32.6	35.5	35.7			2.68
	Cannon		L-C	629.5	641.7	548.4	592.4	603.0			33.09

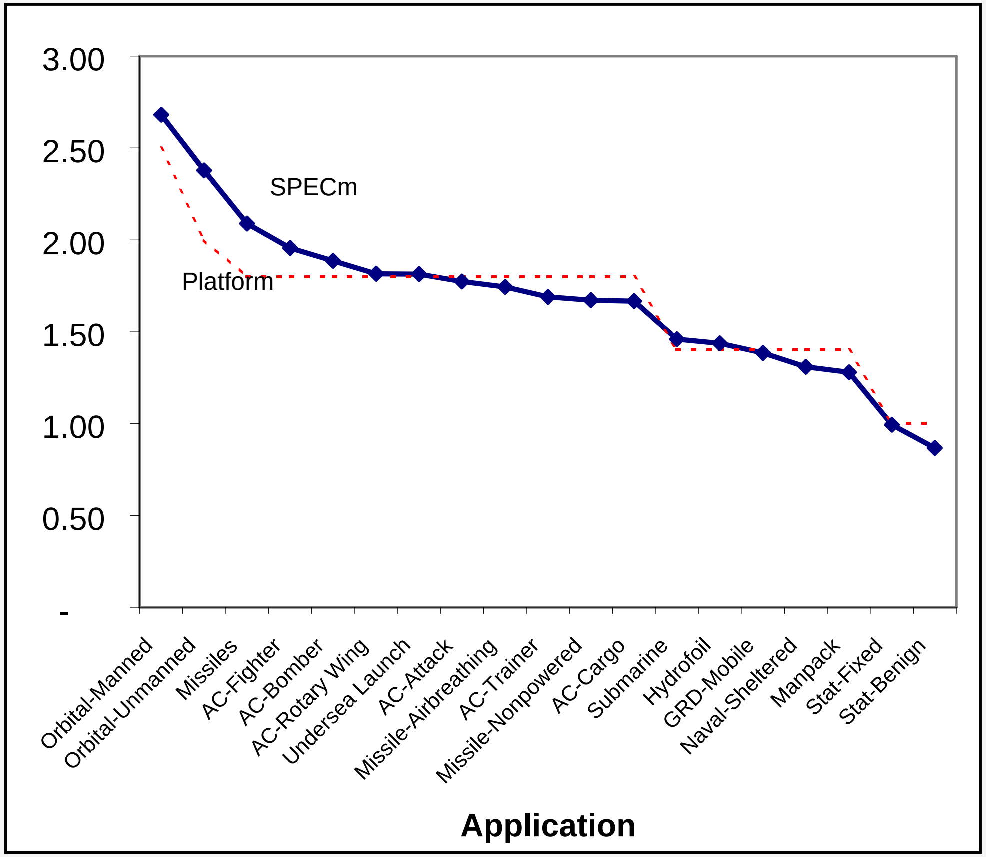
Composite SPECm Development

- Develop performance SPECm as a function of speed
- Develop composite SPECm from environmental de-rating, performance,
- business culture, and reliability /maintainability

Application			Speed		SPECm				
		Weighting>			25%	25%	25%	25%	100%
			Mph	Mach	Performance	DeRating	Business	R&M	Composite
Ground	Stationary	Benign	0.1	0.00	0.66	0.81	1.00	1.00	0.87
		Fixed	3.0	0.00	0.97	1.00	1.00	1.00	0.99
Mobile	Ground	Manpack	10.0	0.01	1.12	1.32	1.30	1.38	1.28
		Mobile	90.0	0.12	1.44	1.42	1.30	1.38	1.38
	Naval	Submarine	40.0	0.05	1.31	1.13	1.70	1.70	1.46
		Sheltered	34.0	0.05	1.29	1.19	1.38	1.38	1.31
		Hydrofoil	55.0	0.07	1.36	1.63	1.38	1.38	1.44
Airborne	Aircraft	Rotary Wing	184.2	0.25	1.56	2.05	1.80	1.85	1.82
		Trainer	446.6	0.60	1.73	1.48	1.80	1.75	1.69
		Cargo	477.6	0.64	1.74	1.32	1.80	1.80	1.67
		Attack	574.1	0.77	1.78	1.71	1.80	1.80	1.77
		Bomber	731.0	0.99	1.83	2.11	1.80	1.80	1.89
		Fighter	1,398.4	1.89	1.97	2.25	1.80	1.80	1.96
Launch	Suborbital	Nonpowered	500.0	0.67	1.75	1.33	1.80	1.80	1.67
		Airbreathing	680.0	0.92	1.81	1.56	1.80	1.80	1.74
		Undersea	80.0	0.11	1.42	2.44	1.70	1.70	1.81
		Missiles	2,223.0	3.00	2.08	2.68	1.80	1.80	2.09
		Cannon	300.0	0.40	1.65	33.09	1.20	1.38	9.33
	Orbit	Unmanned	18,000.0	24.29	2.64	2.68	2.39	1.80	2.38
		Manned	18,000.0	24.29	2.64	2.68	3.00	2.40	2.68

SPECm versus Platform

	SPECm	Platform
Cannon	9.33	
Orbital-Manned	2.68	2.5
Orbital-Unmanne	2.38	2
Missiles	2.09	1.8
AC-Fighter	1.96	1.8
AC-Bomber	1.89	1.8
AC-Rotary Wing	1.82	1.8
Undersea Launch	1.81	1.8
AC-Attack	1.77	1.8
Missile-Airbreathi	1.74	1.8
AC-Trainer	1.69	1.8
Missile-Nonpowe	1.67	1.8
AC-Cargo	1.67	1.8
Submarine	1.46	1.4
Hydrofoil	1.44	1.4
GRD-Mobile	1.38	1.4
Naval-Sheltered	1.31	1.4
Manpack	1.28	1.4
Stat-Fixed	0.99	1
Stat-Benign	0.87	1



Environmental DeRating as a Cost Driver

Results

- **Param equation**
  - SPECm replaces Platform in the Platform generator
  - Developed a simple continuous function for moving manufacturing cost complexity between operating environments
  - Function interpolates horizontally and vertically
- **Increased understanding and fidelity of the platform table**
  - Speed as a Platform (SPECm) generator
  - Relate reliability environmental de-rating factors to Platform (SPECm)
    - Habitation -Inhabited and Uninhabited
    - Shelter - Sheltered and Unsheltered
    - Ground Mobile into
      - Naval - Submarine, Hydrofoil, Surface
      - Mobile - Manpack, Motorized
      - Military Air - Trainer, Cargo, Rotary Wing, Attack, Fighter, Bomber, Missile
    - Added Launch - Undersea, Cannon

Environmental DeRating as a Cost Driver

Authors

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