MIL-HDBK-338: Environmental Conversion Table Correction

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Introduction

- In reliability analysis, especially for launch vehicles, limited data is frequently a problem
- Component data from other environments must be used
- MIL-HBK-338 has a matrix showing the conversation between environments
  - Due to round off the conversions are not commutative, converting from A to B will not equal converting from B to A

Agenda

- Introduction to environment conversions
- Original table
- Original table with edits
- How big is the problem?
- First attempt at correction
- Proposed solution
- Summary

Introduction to environment conversions

- The Reliability Analysis Center (RAC) is chartered by the DoD to collect, analyze, and disseminate data and information.
- The RAC publishes reliability information in the Electric Parts Reliability Data (EPRD) and the Non-electric Parts Reliability Data (NPRD) Reports
- Each failure rate is defined by an environment

1. **Gb= Ground Benign**
2. **Gf= Ground Fixed**
3. **Gm= Ground Mobile**
4. **Ns= Naval Sheltered**
5. **Nu= Naval Unsheltered**
6. **Aic= Airborne Inhabited Cargo**
7. **Aif= Airborne Inhabited Fighter**
8. **Auc= Airborne Uninhabited Cargo**
9. **Auf= Airborne Uninhabited Fighter**
10. **Arw= Airborne Rotary Wing**
11. **Sf= Space Flight**

Original Table as it Appears

- From page 803 of MIL-HDBK-338B

TABLE 10.3-3: ENVIRONMENTAL CONVERSION FACTORS
(MULTIPLY SERIES MTBF BY)

From Environment	To Environment: G_B	G_F	G_M	N_S	N_U	A_{IC}	A_{IF}	A_{UC}	A_{UF}	A_{RW}	S_F
G_B	X	0.5	0.2	0.3	0.1	0.3	0.2	0.1	0.1	0.1	1.2
G_F	1.9	X	0.4	0.6	0.3	0.6	0.4	0.2	0.1	0.2	2.2
G_M	4.6	2.5	X	1.4	0.7	1.4	0.9	0.6	0.3	0.5	5.4
N_S	3.3	1.8	0.7	X	0.5	1.0	0.7	0.4	0.2	0.3	3.8
N_U	7.2	3.9	1.6	2.2	X	2.2	1.4	0.9	0.5	0.7	8.3
A_{IC}	3.3	1.8	0.7	1.0	0.5	X	0.7	0.4	0.2	0.3	3.9
A_{IF}	5.0	2.7	1.1	1.5	0.7	1.5	X	0.6	0.4	0.5	5.8
A_{UC}	8.2	4.4	1.8	2.5	1.2	2.5	1.6	X	0.6	0.8	9.5
A_{UF}	14.1	7.6	3.1	4.4	2.0	4.2	2.8	1.7	X	1.4	16.4
A_{RW}	10.2	5.5	2.2	3.2	1.4	3.1	2.1	1.3	0.7	X	11.9
S_F	0.9	0.5	0.2	0.3	0.1	0.3	0.2	0.1	0.1	0.1	X

Environmental Factors as Defined in MIL-HDBK-217

Original Table with Better Organization

- This table should provide reciprocal answers
  - Sf to Gb conversion = SfGb * MTBF = (0.9 *1,000) to **1 in 900**
  - Gb to Sf = GbSf *MTBF= (1.2***900**) to 1 in 1,080
- Which one is correct?
  - Should it be SfGb= 0.9 and GbSf= 1/.9 or 1.1111
  - Or SfGb= 1/1.2 = .8333 and GbSf

	Gb	Gf	Gm	Ns	Nu	Aic	Aif	Auc	Auf	Arw	Sf
Gb		0.5	0.2	0.3	0.1	0.3	0.2	0.1	0.1	0.1	1.2
Gf	1.9		0.4	0.6	0.3	0.6	0.4	0.2	0.1	0.2	2.2
Gm	4.6	2.5		1.4	0.7	1.4	0.9	0.6	0.3	0.5	5.4
Ns	3.3	1.8	0.7		0.5	1	0.7	0.4	0.2	0.3	3.8
Nu	7.2	3.9	1.6	2.2		2.2	1.4	0.9	0.5	0.7	8.3
Aic	3.3	1.8	0.7	1	0.5		0.7	0.4	0.2	0.3	3.9
Aif	5	2.7	1.1	1.5	0.7	1.5		0.6	0.4	0.5	5.8
Auc	8.2	4.4	1.8	2.5	1.2	2.5	1.6		0.6	0.8	9.5
Auf	14.1	7.6	3.1	4.4	2	4.2	2.8	1.7		1.4	16.4
Arw	10.2	5.5	2.2	3.2	1.4	3.1	2.1	1.3	0.7		11.9
Sf	0.9	0.5	0.2	0.3	0.1	0.3	0.2	0.1	0.1	0.1	

How Big is This Problem?

- Let's continue with the same example as before, so if SfGb is 0.9 then GbSf should be 1.1111 not 1.2 therefore percent error is 7.4% off
- The table below shows the extent of the problem by fixing the lower half and then comparing the percent difference with the original table with:
  - 0-2% is green
  - 2-5% is yellow
  - >5% is red
- Maximum error is 39%! The average is ~9%

	Gb	Gf	Gm	Ns	Nu	Aic	Aif	Auc	Auf	Arw	Sf
Gb		5.3%	8.7%	1.0%	38.9%	1.0%	0.0%	22.0%	29.1%	2.0%	7.4%
Gf			0.0%	7.4%	14.5%	7.4%	7.4%	13.6%	31.6%	9.1%	9.1%
Gm				2.0%	10.7%	2.0%	1.0%	7.4%	7.5%	9.1%	7.4%
Ns					9.1%	0.0%	4.8%	0.0%	13.6%	4.2%	12.3%
Nu						9.1%	2.0%	7.4%	0.0%	2.0%	20.5%
Aic							4.8%	0.0%	19.0%	7.5%	14.5%
Aif								4.2%	10.7%	4.8%	13.8%
Auc									2.0%	3.8%	5.3%
Auf										2.0%	39.0%
Arw											16.0%
Sf											

First Attempt at Correction

- MIL-HDB-217plus updates the table to correct reciprocals but simplifies conversions
  - Much of the differentiation between environments is lost
- This update is not recommend

	GB	GF	GM	NS	NU	AIC	AIF	AUC	AUF	ARW	SF
GB	X	0.5	0.2	0.3	0.1	0.3	0.2	0.1	0.1	0.1	**1.1**
GF	**2**	X	0.4	0.6	0.3	0.6	0.4	0.2	0.1	0.2	**2**
GM	5	2.5	X	1.4	0.7	1.4	0.9	0.6	0.3	0.5	**5**
NS	3.3	**1.7**	0.7	X	0.5	1	0.7	0.4	0.2	0.3	**3.3**
NU	**10**	**3.3**	**1.4**	**2**	X	**2**	1.4	0.9	0.5	0.7	**10**
AIC	3.3	**1.7**	0.7	1	0.5	X	0.7	0.4	0.2	0.3	**3.3**
AIF	5	2.5	1.1	**1.4**	0.7	**1.4**	X	0.6	0.4	0.5	**5**
AUC	**10**	**5**	**1.7**	2.5	**1.1**	2.5	**1.7**	X	0.6	0.8	**10**
AUF	**10**	**10**	**3.3**	**5**	2	**5**	**2.5**	1.7	X	1.4	**10**
ARW	**10**	**5**	**2**	**3.3**	1.4	**3.3**	**2**	1.3	0.7	X	**10**
SF	0.9	0.5	0.2	0.3	0.1	0.3	0.2	0.1	0.1	0.1	X

Proposed Solution

- In any conversion pair, use the greater number and then actually use the reciprocal in the calculation or at least three significant figures
- The table below should be used
  - White shows numbers that match the original table
  - Green shows pairs that match consistently from the original table
  - Yellow shows numbers that have been updated
- NOTE: This table has not been officially endorsed by NASA! And is merely the opinion of the author

	Gb	Gf	Gm	Ns	Nu	Aic	Aif	Auc	Auf	Arw	Sf
Gb		0.5263	0.2174	0.3030	0.1389	0.3030	0.2	0.1220	0.0709	0.0980	1.2
Gf	1.9		0.4	0.5556	0.2564	0.5556	0.3704	0.2273	0.1316	0.1818	2.2
Gm	4.6	2.5		1.4	0.625	1.4	0.9091	0.5556	0.3226	0.4545	5.4
Ns	3.3	1.8	0.7143		0.4545	1	0.666667	0.4	0.2273	0.3125	3.8
Nu	7.2	3.9	1.6	2.2		2.2	1.4	0.833333	0.5	0.7143	8.3
Aic	3.3	1.8	0.7143	1	0.5		0.6667	0.4	0.2381	0.3226	3.9
Aif	5	2.7	1.1	1.5	0.7143	1.5		0.6250	0.3571	0.4762	5.8
Auc	8.2	4.4	1.8	2.5	1.2	2.5	1.6		0.5882	0.7692	9.5
Auf	14.1	7.6	3.1	4.4	2	4.2	2.8	1.7		1.4	16.4
Arw	10.2	5.5	2.2	3.2	1.4	3.1	2.1	1.3	0.7143		11.9
Sf	0.8333	0.4545	0.1852	0.2632	0.1205	0.2564	0.1724	0.1053	0.0610	0.0840	

Summary

- While this table is in “Military Electronic Design Handbook” it is also used to convert non-electronic component reliabilities
  - It must be clear that this is an assumption and the table is based on reliability analysis base on electronic components in different environments
- When converting failure rates between environments, the uncertainty in the failure rate typically increases
  - This progress is outlined in the RAM IX Training Summit report, "Impacts of Source Data Applicability on Epistemic Uncertainty for Launch Vehicle Reliability Models."

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