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INTERNAL NOTE

MODELING NUCLEAR VULNERABILITY
OF NATO TACTICAL AIRFIELDS

Felix Kozaczka

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PREFACE

ARPA and OSD/DDPA&E have recently funded a Rand study consisting of two tasks. Task 1 will examine the vulnerability of NATO land-based aircraft, bases and nuclear weapons to nuclear attack by the Soviet Union. Different levels of Soviet attack will be considered by a variety of Soviet aircraft and missile systems. Means of improving the survivability of NATO land-based tactical air nuclear capability will be investigated. Task 2 will examine the vulnerability of nuclear capability associated with NATO ground forces to nuclear attack. Deficiencies in measures currently being used to provide for survival of NATO ground force nuclear capability will be identified and measures to correct deficiencies will be examined. The collateral damage associated with attacks on tactical air nuclear capabilities and on ground force nuclear capabilities will be calculated.

This Internal Note briefly describes preliminary work done in modeling the vulnerability of NATO tactical airfields. The primary analytical tool is a portion of the TANDEM model. A description of the model is contained in WN-7920-ARPA, *A General Description of the Tactical Nuclear Damage Evaluation Model (TANDEM) (U)*, by M. G. Weiner and L. H. Wegner, August 1972, Secret.

One of the tasks of the NATO Nuclear Survivability Study is to examine the vulnerability of NATO land-based aircraft, bases, and nuclear weapons to nuclear attack by the Soviet Union. Different levels of Soviet attack by a variety of Soviet aircraft and missile systems will be considered. The objectives of the study include assessment of post attack capability of NATO tactical aircraft and bases, identifying which elements of NATO bases are most vulnerable, and proposing means for reducing this vulnerability.

As a first step, we are examining in detail the effects of nuclear attacks of varying severity against a single NATO airbase -- Bitburg. If the results of the Bitburg analysis appear fruitful and it appears feasible to do so, we may extend this analysis to other bases. Our primary analytical tool is TANDEM, the "Tactical Nuclear Damage Evaluation Model," developed by Rand as part of an ARPA study of theater nuclear warfare.

A sub-routine of the TANDEM model, TANDEM A, is designed specifically to estimate the results of nuclear attacks against airbases. TANDEM A has been further refined to calculate damage to any structure or estimate personnel casualties based on target vulnerability and its distance from the point of weapon detonation. In order to exercise this capability, we first identified every significant structure on Bitburg Airbase, using the Base Plan (Tab C-1) of the Master Plan of Bitburg, and measured its distance from a common reference point -- the center of the runway. Each building was also coded as to function based on data taken from the Real Property Inventory List (HQ, USAF RCS SSZ-112). Pending receipt from Bitburg Airbase of the Existing Building Schedule, which identifies in detail the size and construction of all structures on the base, we roughly approximated building size from the Base Plan, and together with the building function assigned a vulnerability number (VN) to each building based on the DIA Vulnerability Handbook for Nuclear Weapons. Both military personnel and their dependents were accounted for by their assumed location at time of detonations, as well as foreign national employees on the base, if appropriate.

One of our objectives in this phase of the study is to identify those elements of the airbase which are most critical to post-attack operation of a base, and those most vulnerable to weapons of varying yield or accuracy. For this purpose, we have placed each of the elements on the base in one of the categories shown in Table 1.

These data were then converted to a machine format for use in the TANDEM model, as described in Table 2. Examples of typical entries are as follows:

GE US xxxxx*	1	060	102	-5740	1680	100	60	020	21PO**	1010	
GE US xxxxx	1	060	847	-2160	7100	220	60	050	14PO	2	
GE US xxxxx	1	060	2048	-2160	7100				63	4	2
GE US xxxxx	1	060	1048	-2160	7100				21	4	2

The first entry indicates that an aircraft shelter is located at a distance 5740 ft to the left of the center of the runway on a plane perpendicular to the reference point, and 1680 ft above a plane parallel to the reference point. The shelter is 100 ft long, 60 ft wide, and it is oriented 020⁰ from a line perpendicular to the runway bearing. The VN number assigned to this structure is 21PO; it is Building No. 1010 on the Bitburg Base Plan.

The second entry indicates that this structure is in the family housing category; the appropriate distance, size, orientation and VN numbers are entered. As can be seen from the next two entries, they depict personnel assumed to be in that particular building; 63 military dependents and 21 military personnel are considered occupants of this building at time of detonation.

Our preliminary examination of Bitburg identified 567 separate buildings, structures, aircraft, and groups of personnel at Bitburg which were considered significant, each entered in the TANDEM program in the described format. The only additional steps necessary in the anti-airfield sub-program are to enter the weapon or weapons used in

* Number is classified when related to specific installation.

** These are illustrative VNs only.

Table 1

ELEMENT CATEGORIES

<u>No.</u>	<u>Identifier</u>
1-5	Runways
6-10	Taxiways
11-99	Revetments
100-199	Shelters
200-239	Underground hangars
240-399	Aircraft
400-429	Operations facilities (offices, ready rooms, planning, etc.)
430-439	Aerology, navigation, approach control, lighting, facilities, etc.)
450-479	POL facilities
480-499	Aircraft services (AGE, 483L, transportation maintenance)
500-529	Maintenance (hangars, shops, etc.)
530-549	Automotive & heavy equipment maintenance & storage
550-579	Ordnance storage
580-599	Ordnance handling (payload & weapon assembly)
600-609	Transportation
610-619	Headquarters, command posts
620-649	Administration (including recreation) buildings
650-679	Supply
680-684	Dining facilities
685-699	Power facilities
700-709	Water supply
710-719	Heating facilities
720-729	Medical facilities
730-769	Other support (e.g., personnel shelters)
770-799	Defenses
800-899	Barracks, BOQs
900-999	Family housing, base exchange, chapel, etc.
1000-1949	Military personnel
2000-2299	Military dependents
2300-2399	Foreign national (indigenous hire)

Table 2

MACHINE FORMAT

<u>COLUMNS</u>	<u>DATA</u>	<u>EXPLANATORY NOTES</u>
1-2	Country location	Abbreviation (i.e., GE = Germany)
4-5	User nation	U.S., UK, GE, etc.
6-10	Category number	A category number from a listing of categories of installations in the DIA Contingency Planning Facilities List Program Handbook. These numbers are consistent with the numbers used in the overall TANDEM data base.
12-14	Sequence number	The sequence number of this installation in the overall airfield data base.
16-18	Runway orientation	Orientation from true or magnetic north.
20-22	Element number	Element category in which this unit falls in accordance with Table 1.
24-28	X Coordinate	Horizontal distance from reference point (in feet).
29-33	Y Coordinate	Vertical distance from reference point.
35-39	Length/radius	Length or radius of building if applicable.
40-42	Width	Width of building.
44-46	Element orientation to runway	Used in assessing damage to some building targets.
48-50	Number of aircraft or people	
52-54	Type aircraft	Numerically coded.
56-59	Vulnerability or personnel effects number	Based on DIA Vulnerability Handbook for Nuclear Weapons.
61-75	Remarks	
76-80	Building number	Taken from base master plan.

the attack in terms of Desired Ground Zero (DGZ), entered as X and Y distances from the reference point, weapon yield, height of burst and CEP.

The initial printout format is shown in Tables 3 and 4. Table 3 shows the probability of kill for each of the 567 elements (buildings, structures, aircraft, or personnel groupings) identified on the airfield for a particular weapon yield, burst height and CEP. Table 4 summarizes damage to element categories by PK frequency distribution, and separately displays damage to aircraft and personnel casualties. As can be seen from the illustration, no foreign nationals were assumed on the base at time of detonation.

Subsequent classified notes will provide information on input data and progress reports on our work.

Table 3

ELEMENT PK'S FROM WEAPONS 1 TO 1

	1	2	3	4	5	6	7	8	9	10
	FLFM PK	FLFM PK	FLFM PK	FLFM PK	FLFM PK	FLFM PK	FLFM PK	FLFM PK	FLFM PK	FLFM PK
1- 10	2047 0.23	1047 0.23	947 0.0	2048 0.21	1048 0.21	948 0.0	2049 0.18	1049 0.18	949 0.0	2046 0.11
11- 20	1040 0.11	940 0.0	950 0.0	1027 0.17	2027 0.17	1045 0.10	2045 0.10	945 0.0	2047 0.08	1047 0.08
21- 30	947 0.0	2043 0.06	1043 0.06	943 0.0	2044 0.06	1044 0.06	944 0.0	2000 0.08	1000 0.08	500 0.0
31- 40	2001 0.07	1001 0.07	901 0.0	1038 0.06	2038 0.06	902 0.0	2002 0.06	1002 0.06	903 0.0	1039 0.05
41- 50	2039 0.05	904 0.0	2003 0.05	1003 0.05	905 0.0	1040 0.04	2040 0.04	906 0.0	2004 0.04	1004 0.04
51- 60	907 0.0	1041 0.03	2041 0.03	908 0.0	2005 0.03	1005 0.03	909 0.0	2032 0.02	1032 0.02	941 0.0
61- 70	2006 0.03	1006 0.03	911 0.0	2007 0.02	1007 0.02	912 0.0	2008 0.02	1008 0.02	913 0.0	2009 0.02
71- 80	1009 0.02	914 0.0	2033 0.03	1033 0.03	915 0.0	2010 0.02	1010 0.02	916 0.0	2011 0.02	1011 0.02
81- 90	917 0.0	2034 0.03	1034 0.03	918 0.0	2012 0.02	1012 0.02	919 0.0	2013 0.03	1013 0.03	920 0.0
91-100	2035 0.04	1035 0.04	921 0.0	2014 0.03	1014 0.03	922 0.0	2015 0.03	1015 0.03	923 0.0	2016 0.03
101-110	1016 0.03	924 0.0	2036 0.04	1036 0.04	925 0.0	2017 0.04	1017 0.04	926 0.0	2037 0.05	1037 0.05
111-120	927 0.0	2018 0.05	1018 0.05	928 0.0	2019 0.06	1019 0.06	929 0.0	1029 0.06	2029 0.06	930 0.0
121-130	2020 0.08	1020 0.08	931 0.0	1030 0.08	2030 0.08	932 0.0	2021 0.09	1021 0.09	933 0.0	2022 0.11
131-140	1022 0.11	934 0.0	1031 0.10	2031 0.10	935 0.0	2023 0.12	1023 0.12	936 0.0	2024 0.15	1024 0.15
141-150	937 0.0	2025 0.13	1025 0.13	938 0.0	2026 0.15	1026 0.15	939 0.0	2028 0.14	1028 0.14	940 0.0
151-160	910 0.0	710 0.0	960 0.0	952 0.0	951 0.0	961 0.0	962 0.0	958 0.0	957 0.0	953 0.0
161-170	721 0.0	1073 0.11	722 0.0	953 0.0	639 0.0	1077 0.11	1075 0.14	812 0.0	955 0.0	503 0.0
171-180	637 0.0	636 0.0	1074 0.13	954 0.0	540 0.0	538 0.0	539 0.0	454 0.0	959 0.0	701 0.0
181-190	954 0.0	1051 0.65	800 0.0	1022 0.08	801 0.0	680 0.0	1053 0.73	802 0.0	1054 0.73	803 0.0
191-200	1055 0.75	804 0.0	1056 0.78	805 0.0	1059 0.73	816 0.0	710 0.0	684 0.0	1060 0.80	810 0.0
201-210	1061 0.82	811 0.0	1062 0.83	809 0.0	733 0.00	611 0.01	612 0.0	734 0.19	735 0.29	1055 0.76
211-220	400 0.0	681 0.0	610 0.0	737 0.0	1057 0.68	606 0.0	1058 0.70	607 0.0	1066 0.80	814 0.0
221-230	620 0.0	671 0.0	500 0.0	1064 0.91	808 0.00	700 0.0	730 0.0	731 0.0	455 0.0	670 0.0
231-240	640 0.0	650 0.0	671 0.00	516 0.01	694 0.0	685 0.0	693 0.01	761 0.0	762 0.0	763 0.0
241-250	764 0.0	765 0.0	741 0.00	530 0.01	744 0.00	623 0.05	1076 0.91	633 0.01	531 0.02	738 0.02
251-260	653 0.12	1066 0.89	430 0.00	745 0.06	1065 0.90	613 0.09	739 0.00	622 0.0	634 0.05	635 0.11
261-270	720 0.14	625 0.50	480 0.50	711 0.05	655 0.82	1067 0.84	613 0.0	740 0.00	737 0.03	482 0.61
271-280	534 0.16	533 0.12	532 0.02	1070 0.93	624 0.31	749 0.87	751 0.80	481 0.43	650 0.76	493 0.56
281-290	687 0.08	1071 0.97	695 0.0	696 0.0	766 0.0	768 0.0	1069 0.81	614 0.0	682 0.0	651 0.05
291-300	401 0.0	652 0.09	746 0.0	683 0.17	750 0.55	743 0.01	983 0.23	650 0.0	747 0.01	486 0.62
301-310	295 0.31	501 0.31	296 0.69	503 0.69	487 0.83	403 0.97	402 0.96	413 0.96	485 0.59	638 0.59
311-320	491 0.98	488 0.67	815 0.97	537 0.38	752 0.98	628 0.99	502 0.63	654 0.91	755 0.97	492 0.25
321-330	626 0.93	504 0.90	517 0.94	505 0.91	506 0.95	712 0.41	607 0.77	608 1.00	405 0.13	535 0.25
331-340	490 1.00	657 1.00	515 0.96	489 0.90	484 0.49	431 0.67	406 0.10	451 0.08	660 0.68	536 0.05
341-350	441 0.74	636 0.21	697 0.35	699 0.0	698 0.00	767 0.29	457 0.10	458 0.04	455 0.15	460 0.05
351-360	461 0.14	462 0.06	463 0.16	661 0.15	753 0.59	666 0.08	659 0.26	754 0.46	627 0.47	404 0.15
361-370	756 1.00	405 0.29	432 0.26	633 0.23	434 0.26	435 0.24	757 0.12	758 0.09	650 0.11	759 0.06
371-380	760 0.13	629 0.18	660 0.10	667 0.16	450 0.0	464 0.08	506 0.0	507 0.0	560 0.0	417 0.04
381-390	550 0.0	557 0.0	558 0.0	559 0.0	560 0.0	561 0.0	562 0.0	563 0.0	564 0.0	565 0.0
391-400	408 0.0	569 0.0	570 0.0	512 0.00	691 0.00	513 0.00	514 0.0	714 0.0	651 0.0	494 0.0
401-410	603 0.0	298 0.0	1072 0.64	411 0.0	410 0.0	609 0.0	604 0.0	493 0.0	715 0.00	697 0.0
411-420	662 0.0	664 0.0	550 0.0	492 0.01	632 0.01	630 0.17	407 0.0	690 0.27	580 0.01	440 0.12
421-430	665 0.0	507 0.68	508 0.63	509 0.58	510 0.52	511 0.48	748 0.22	582 0.0	581 0.0	551 0.0
431-440	552 0.0	553 0.0	554 0.0	555 0.0	584 0.0	583 0.0	259 0.0	100 0.0	111 0.0	260 0.0
441-450	261 0.0	108 0.0	262 0.0	110 0.0	263 0.0	109 0.0	264 0.0	101 0.0	265 0.0	104 0.0
451-460	266 0.0	105 0.0	267 0.0	102 0.0	268 0.0	103 0.0	269 0.0	106 0.0	107 0.0	270 0.0
461-470	113 0.0	112 0.0	114 0.0	271 0.0	115 0.0	272 0.0	116 0.0	273 0.0	118 0.0	274 0.0
471-480	117 0.0	275 0.0	119 0.0	276 0.0	120 0.0	277 0.71	121 0.0	278 0.88	122 0.0	279 0.76
481-490	123 0.0	280 0.66	124 0.0	281 0.59	125 0.0	282 0.82	126 0.0	283 0.56	127 0.0	284 0.55
491-500	128 0.0	285 0.78	129 0.0	286 0.62	130 0.0	287 0.55	131 0.0	288 0.82	132 0.0	289 0.94
501-510	133 0.0	290 0.93	134 0.0	291 0.91	135 0.0	292 0.88	136 0.0	293 0.74	137 0.0	138 0.0
511-520	294 0.81	139 0.0	140 0.0	141 0.0	142 0.0	143 0.0	144 0.0	145 0.0	146 0.0	147 0.0
521-530	148 0.0	149 0.0	249 0.02	150 0.0	250 0.00	151 0.0	251 0.01	152 0.0	252 0.00	153 0.0
531-540	253 0.00	154 0.0	254 0.0	155 0.0	255 0.0	156 0.0	248 0.0	157 0.0	250 0.0	158 0.0
541-550	257 0.0	159 0.0	258 0.0	257 0.0	160 0.0	161 0.0	240 0.0	162 0.0	241 0.0	163 0.0
551-560	242 0.0	164 0.0	243 0.0	165 0.0	244 0.0	166 0.0	245 0.0	167 0.0	246 0.0	168 0.0
561-567	247 0.0	169 0.0	170 0.0	171 0.0	172 0.0	1 0.007	0 0.007			

Table 4

DAMAGE SUMMARY FOR WEAPONS 1 TO 1

ELEMENT RANGE	CATEGORY	NUMBER OF ELEMENTS	AVE. PK	PK FREQUENCY DISTRIBUTION										
				0	.01-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1.0
1-5	RUNWAYS	1	0.07	0	1	0	0	0	0	0	0	0	0	0
6-10	TAXIWAYS	1	0.07	0	1	0	0	0	0	0	0	0	0	0
100-199	SHELTERS	73	0.0	73	0	0	0	0	0	0	0	0	0	0
200-299	AIRCRAFT	59	0.25	38	1	0	0	1	0	4	3	4	5	3
300-399	OPERATIONS FACILITIES	14	0.25	7	1	2	1	0	0	0	0	0	0	3
400-499	AFK., NAV., ETC. FAC.	6	0.27	1	0	0	4	0	0	0	1	0	0	0
500-599	POL FACILITIES	18	0.12	5	5	6	1	0	0	0	1	0	0	0
600-699	AIRCRAFT SERVICES	16	0.53	3	0	0	1	0	2	3	3	0	1	3
700-799	MAINTENANCE	18	0.43	4	1	0	0	1	4	2	4	0	0	2
800-899	AUTOMOTIVE MAINT. ETC	11	0.09	4	3	2	1	1	0	0	0	0	0	0
900-999	ORDNANCE STORAGE	21	0.0	21	0	0	0	0	0	0	0	0	0	0
1000-1999	ORDNANCE HANDLING	5	0.00	5	0	0	0	0	0	0	0	0	0	0
2000-2999	HEADQUARTERS, CP'S	5	0.02	3	2	0	0	0	0	0	0	0	0	0
3000-3999	ADMINISTRATION BLDGS	21	0.23	9	3	3	0	1	2	0	0	0	0	3
4000-4999	SUPPLY	22	0.24	9	3	4	1	0	0	0	1	1	1	2
5000-5999	DINING FACILITIES	5	0.03	4	0	1	0	0	0	0	0	0	0	0
6000-6999	POWER FACILITIES	15	0.18	9	1	0	2	1	0	0	1	0	0	1
7000-7999	WATER SUPPLY	2	0.0	2	0	0	0	0	0	0	0	0	0	0
8000-8999	HEATING FACILITIES	6	0.07	4	1	0	0	0	1	0	0	0	0	0
9000-9999	MEDICAL FACILITIES	3	0.05	2	0	1	0	0	0	0	0	0	0	0
10000-19999	OTHER SUPPORT	37	0.21	17	7	2	3	0	1	2	0	0	2	3
20000-29999	BARRACKS, BUNGS	17	0.06	16	0	0	0	0	0	0	0	0	0	1
30000-39999	FAMILY HOUSING	64	0.0	64	0	0	0	0	0	0	0	0	0	0
40000-49999	MILITARY PERSONNEL	77	0.29	0	39	13	2	0	0	0	5	7	6	5
50000-59999	MILITARY DEPENDENTS	50	0.07	0	39	9	2	0	0	0	0	0	0	0

TOTAL DESTROYED

AIRCRAFT	66	16.2
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TOTAL CASUALTIES

MILITARY PERSONNEL	3001	1541.7
MILITARY DEPENDENTS	3150	223.6