A Mathematical Probability of Success for Soviets in Cold War Confrontation

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Editor's Note: This article is part one of a two-part series on the Soviet correlation of forces and means.

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Introduction

Who will be in the Final Four during March Madness? Which horse will win in the Kentucky Derby? Who has the better tank, the Americans or the Russians? The answer to these questions is based on past performance, statistics, hype and, too often, wistful guessing or a hunch. This may be adequate when the bet is ten dollars in an office pool, but better analysis and predictability are necessary when lives and national survival are at stake.

The notion that the inherent values of various weapons and systems (and the personnel who man them) can be measured and compared against a single quantitative standard is as contentious as is developing an infallible system for the quantification of battle. Yet the Soviets long pursued mathematizing battle. Intuitively, the military practitioner may suspect the existence of such a relationship, but proving it is very difficult. Historical studies have not yet revealed an infallible system for determining the total quantification of combat or operations, and perhaps they never will. Regardless, Soviet military scientists searched for objectivity and optimization in military affairs by using

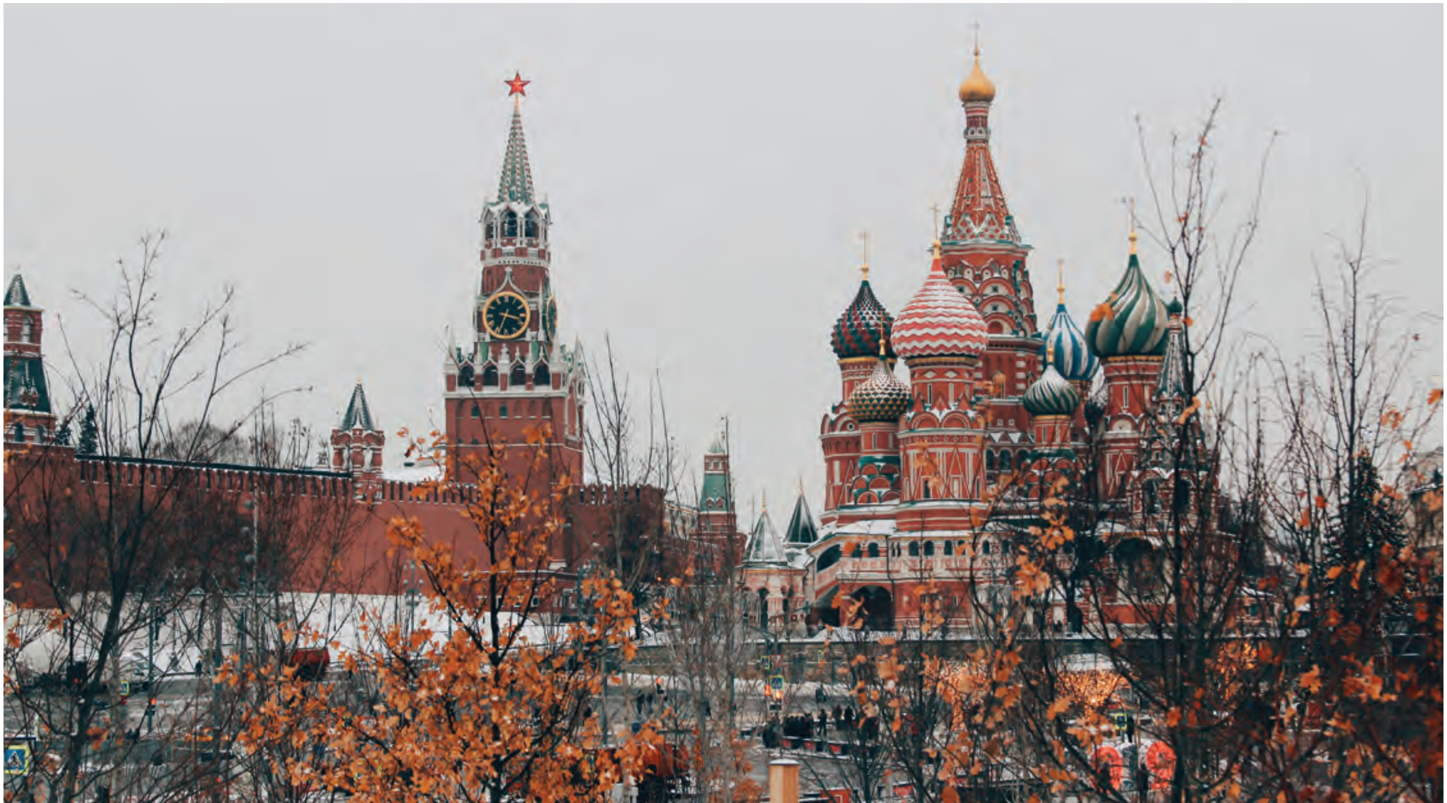


Photo by Michael Parulava on Unsplash

The Kremlin, Moscow, Russia, on January 14, 2019.

military operations research to reduce tactical and technical aspects of military science to measurable, objective indices from which decisions could be made or otherwise substantiated. A sub-element of Soviet military operations research was the correlation of forces and means (COFM) methodology. COFM was considered a powerful tool for helping operational- and tactical-level commanders in their decision-making processes. The Soviet definition of COFM was—

> ***The Correlation of Forces and Means [Соотношение сил и средств] is determined by comparing the quantitative and qualitative characteristics of subunits, units, formations, weapons, military equipment, etc., of one's own forces with those of the enemy. This provides an objective indicator of the combat power and the operational/tactical potentials of the opposing sides and allows one side the opportunity to take measures to gain superiority over the other side. The correlation of forces and means (COFM) exerts great influence (sometimes the deciding influence) on operational and tactical plans during their preparation and refinement with the aim of the timely determination and support for the necessary superiority over the enemy on the selected axes.***[1]

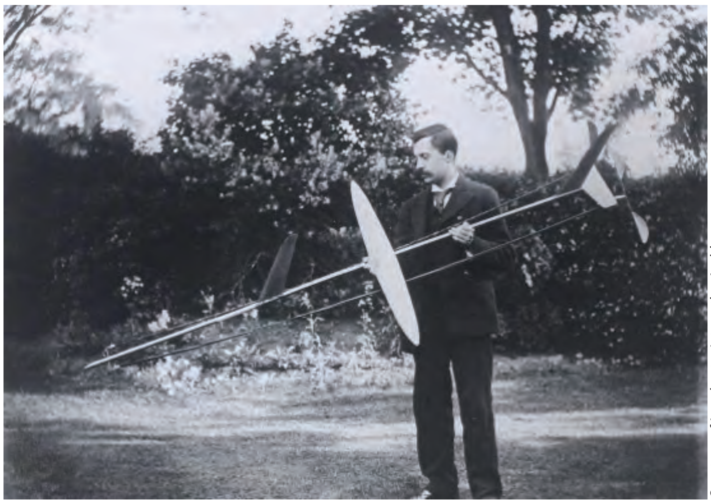
As with all operations research-related techniques, COFM's focus was toward the ultimate "goal" of a particular task—specifically, the direct numerical comparison of forces. Its principal mechanisms were (1) the quantification of selected battlefield elements, and (2) the mathematical expressions (or formulae) that related those elements in such a manner to support decision making. These mechanisms were used to develop conclusions about the status of opposing combatants at particular stages of the unfolding battle.[2]

Pre-Soviet and Soviet Development of Strategic Decision Models

The Russians have a long history of developing the mathematical determination of combat.[3] Beginning in the 1850s, military wargames employing rudimentary mathematics were part of the training of general staff officers. In 1884, Nikolai Volotsky directly applied mathematical means (including probability theory) to solving wartime ammunition supply problems.[4] By the outbreak of World War I, prominent military and civilian writers were mathematizing the theories of modern combat. Of particular significance were the contributions of M. Osipov,[5] working independently of Frederick W. Lanchester,[6] which derived a series of finite difference equations for predicting combat outcomes. He developed his "theory of losses" from an analysis of 38 historical battles fought between 1805 and 1905. Osipov's formulae were an excellent starting point for forecasting battle outcomes and optimizing one's forces. Osipov's work served as historical substantiation of the interrelationship of mathematics and armed conflict. Several decades later, Soviet mathematicians would expand and refine his basic equations to include the consideration of randomness and battlefield variables.[7]

By the mid-1950s, the Communist Party and state leadership determined that it could not resolve complex national security issues without serious scientific support. This resulted in the creation of a wide network of scientific research institutes (SRIs), which were charged with providing support for preparing and making strategic decisions. Their structures corresponded to the structures and missions of the organizations to which they belonged. The fundamental areas that SRI research and development focused on were methodologies, quantitative methods, and mathematical models to support decision making at all command levels in the Ministry of Defense, General Staff, and armed services. Automation of command and control for the higher-level staffs and field units was particularly important.[8] SRI research topics in support of the General Staff included developing—

- ✦ A system of models and mathematical methods to support planning strategic nuclear strikes and evaluating the results.
- ✦ Systems of mathematical models to forecast the course and outcome of conflict in theater operations; front and army operations; and tactical combat of ground force divisions, air defense, and aviation. (A *front* is roughly an army group of three to five armies.)
- ✦ Models to automate and provide information support to the General Staff and high-level staffs.
- ✦ Systems of models to support mobilization, weapons development, and military technology.[9]



Courtesy of Lanchester Interactive Archive

Frederick Lanchester experimenting with his glider at his home in Birmingham, UK, 1894. Frederick W. Lanchester (1868–1946), an English mathematician and engineer who designed automobiles, postulated the theory of aerodynamics.

Well-known scientists led the SRIs, and they gathered the top talent from among the graduates of the Soviet Union's leading civilian and military universities and academies. The SRIs offered good working locations and top salaries. A supporting infrastructure of computer, communications, information, and database centers was developed to support their work. Modeling helped design and optimize this infrastructure.[10]

In the early 1960s, the Lanchester and Osipov mathematical models of combat were studied and applied to the problems of strategic nuclear war using mathematical optimizing methods and game theory. This approach proved impossible in modeling the high degree of uncertainty and complexity of modern ground forces operations. A new approach was needed and developed. It did not attempt to formalize fully the modeled processes. Combat at different scales was represented with algorithmic descriptions of real-time space dynamics or armed combat considering the—

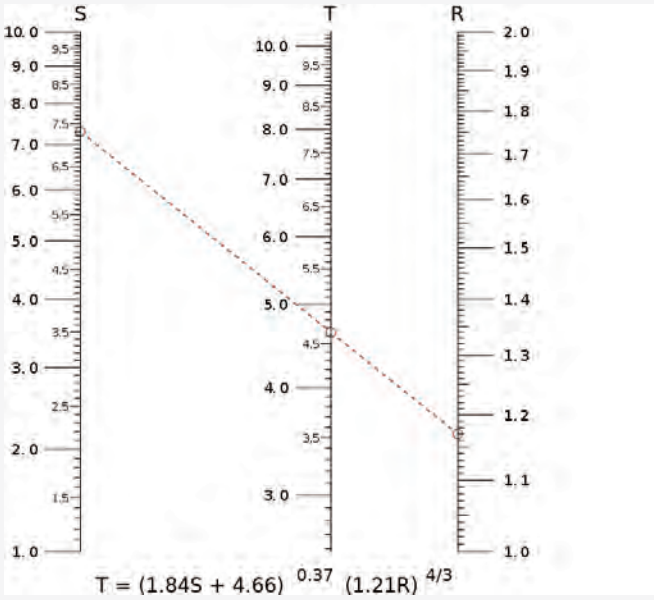
- Specific location of troop formations of both sides.
- Interaction of forces and means in time and space to achieve missions.
- Maneuver of forces and means, the dependence of the outcome on the effectiveness of combat support, and rear area support.
- Uncertainty under which both sides decide and operate.[11]

The algorithmic model describes the sequential nature of logical and quantitative procedures with sufficient accuracy for staff work. An SRI working for the Main Operational Directorate of the General Staff undertook development of the model. It developed models of front and army operations and combined arms combat. The accuracy of the model was tested over a 2-year period by modeling 10 successful Red Army front ground forces operations against the Germans in 1944. Since Soviet and German archival documents exaggerated enemy losses and underreported own losses, the actual manpower losses were determined from supply records indicating daily unit requests for food and ammunition.[12]

The COFM model was supposed to measure combat potential based on calculation units. Depending on the scale, the calculation units could be individual systems, or aggregates of systems in units. At the strategic level, calculation units were divisions while battalions and companies were calculation units at the operational/tactical level. The characterization of division calculation units was in terms of time needed to prepare for operations, rate of movement, time needed to deploy into combat positions, allocation of ammunition and daily support needs, time required to reconstitute combat capabilities after various degrees of losses, and so on. These characteristics are aggregates of the characteristics of lower-level units. Models of the operational and tactical levels represent aspects of armed conflict with sufficient precision to determine the characteristics of the calculation units.[13] This modeling effort was supported by various nomograms, tables, reference books, and developing computer systems.[14]

Nomograms

A nomogram is a diagram representing the relations between and among three or more variable quantities by means of a number of scales, so arranged that the value of one variable can be found by a simple geometric construction, for example, by drawing a straight line intersecting the other scales at the appropriate values.



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A typical parallel-scale nomogram. This example calculates the value of T when S = 7.30 and R = 1.17 are substituted into the equation. The isopleth crosses the scale for T at just under 4.65.

Tactical, Operational, and Strategic COFM of the Cold War Era

North Atlantic Treaty Organization (NATO) Operations Research/Systems Analysis (ORSA) practitioners spent a lot of effort trying to determine Soviet coefficients of combat power and their formulae for determining attack widths; loss of combat effectiveness; effects of terrain, training, morale, nationality, and days of combat; and effects of battlefield reconstitution.[15] Soviet coefficients of combat power were developed for different Soviet and Western weapons systems using fire power, survivability, rates of fire, and mobility. The T-55 tank was used as base one against which to measure other systems.

Coefficient of Combat Power

Assigning a coefficient of combat power to a system against which to measure other systems is hardly a new concept. Beginners to the ancient game of chess learn that the combat potential of a pawn is one. A bishop and a knight are both threes. A rook is a five and a queen is a nine. The king has a combat power of one, but because his capture determines the contest, the king also has a power of infinity. There is a COFM between varying pieces depending on positioning.[16]

Game of Worlds

Table 1 (on the next page) provides details from a 1980 United States intelligence information report on the Soviet coefficients of combat power of tanks, infantry fighting vehicles, infantry personnel carriers, artillery and mortar systems, and antitank weapons.[17] Table 1 lists the coefficients of combat power for individual weapons systems. These coefficients would normally be incorporated into friendly and opposing unit tables of organization and equipment (TO&E) before hostilities. They would be updated based on intelligence as to combat losses and reinforcements. Non-TO&E units would be a concern and require input from intelligence and analysis. Irregular warfare is a challenge for the COFM system. Guerrillas fight as small groups and may have unrated weapons systems such as "technical" vehicles mounting a machine gun, small mortar, or recoilless rifle. Furthermore, guerrillas do not match the conditions of conventional maneuver war—their positions are usually one deep rather than multiple positions incorporated into an integrated defense extending 5 kilometers or more. Table 1 provided the basis for the mathematical determination of tactical and operational COFM, but determining how many enemy systems of what quality will confront the friendly systems is only the beginning, as it aggregates the combat power available to both sides prior to the fight. This merely describes upcoming combat on a billiards table. The friendly and enemy forces would need to be adjusted by the application of mathematical "K" factors—terrain; morale; nationality; training; days of prior combat; logistics support; width of attack sector; whether defending troops are in the open, dug in, or part of a well-engineered defense; current strength; combat losses, and so on. This adjusted COFM could then be used to determine mathematically the width of an attack sector and rate of advance. Soviet officers were well schooled in mathematics and relied on mathematical tools to verify the commander's decision or to adjust the plan to meet the mathematical coefficients that quantify success. The K factors of that time are still not available in open-source—and these made higher tactical and operational calculations possible.

Table 1 provided the ability to determine the aggregate combat power of opposing units for tactical combat and operations. There was no combat potential value for individual soldiers, just weapons systems. The value of soldiers was in the aggregate that is modified by K factors. The combat power model does not allow for cowards or heroes; however, soldiers must be alive and armed to man systems. Mathematical planning at the tactical level was further supported by planning tables, formulae, and nomograms.[18]

Table 1 also supported the determination of tank versus anti-tank combat, air versus air defense combat, and air versus air combat, as well as combined combat/operations using the organic and attached systems of the opposing forces.

Table 2, on page 34**,** provides details from a 1980 United States intelligence information report on the Soviet coefficients of combat potentials of Warsaw Pact and NATO divisions (and the Canadian Battle Group).[19] The Soviet TO&E Motorized Rifle Division equipped with T-55 tanks and BMP infantry fighting vehicles was the base one unit against which other units were valued. The table was developed for the possibility of war in Central Europe; therefore, it does not include the NATO forces of Norway, Italy, and Turkey, nor does it include the Warsaw Pact forces of Hungary, Romania, and Bulgaria. These undoubtedly existed in the planning files of other strategic axes. Again, this information describes operations on a billiards table. The values were adjusted by their own series of "K" factors. Table 2 was the starting point for operational and strategic planning, as it provided the coefficients of combat power of large ground units. Again, without their operational K factors, Table 2 remains as the basic piece of a larger process.

Conclusion

The COFM modeling system was a central tool for Soviet tactical, operational, and strategic planning. It provided mathematical certainty and predictability for conventional maneuver warfare under nuclear-threatened conditions and provided a degree of stability and rationality to maintaining the status quo of the Cold War. The COFM model did not disappear with the collapse of the Soviet Union. Russia has upgraded their COFM model and enhanced its value as a planning tool with improved computing capability and capacity.

Table 1. 1980 United States data on combat potentials of the armament and combat equipment of the ground forces and aviation of the Soview Union and of the armies of their probable enemy

Ground Forces and Aviation of the USSR		Armies of the Probable Enemy	
Nomenclature of Armament	Combat Potential	Nomenclature of Armament	Combat Potential
Tanks, Self-propelled Artillery, Infantry Combat Vehicles, Armored Personnel Carriers			
T-55+	1.00	M60A3	1.40
T-62	1.00	XM-1 experimental	2.50
T-64A	1.50	Leopard-1A4	1.50
T-80	1.80	Leopard-2	2.40
T-64B	2.10	Chieftain Mark-5	1.50
T-72	1.50	AMX-30	1.10
T-72 with D-kl tank gun	1.70	Leopard-1	1.10
T-80 improved	2.80	MBT-80	1.60
T-54B	0.90	M60A2	2.20
T-44	0.75	M60A1	1.10
T-34 with 85mm gun	0.49	Leopard-1A1	1.40
T-10M	1.51	M48, M48A1	1.00
IS-2M	0.70	M47	1.10
IS-3	0.83	M41	0.36
IT-1	0.80	M551	0.83
PT-76	0.48	AMX-13/75mm gun, SS-11B1	0.80
ISU-152	0.79	AMX-13/90mm gun	0.54
SU-122	0.60	T-59	0.90
SU-100	0.55	T-62 (85mm gun)	0.42
SU-85	0.48	T-34 (76mm gun)	0.43
ASU-85	0.21	T-54A	0.90
ASU-57	0.18	T-54	0.87
BMP-1	0.80	Pz-61	0.60
BMD-1	0.80	Pz-68	1.00
BTR, BRDM	0.10	SU-76	0.32
		Marder IFV w/o ATGM	0.10
		Marder IFV w/ ATGM	0.50
Ground Forces and Aviation of the USSR		Armies of the Probable Enemy	
Nomenclature of Armament	Combat Potential	Nomenclature of Armament	Combat Potential
Field Artillery and Mortars			
76mm gun, gun howitzer	0.38	105mm howitzer	0.63
85mm gun	0.42	105mm SP howitzer	0.70
122mm SP howitzer 2S1	0.81	155mm howitzer	0.66
122mm howitzer	0.70	155mm SP howitzer	0.90
122mm gun A-19	0.61	175mm SP gun	0.75
122mm gun A-74	0.66	203.2mm howitzer	0.80
152mm SP howitzer 2S3	0.86	203.2mm SP howitzer	0.84
152mm howitzer	0.71	81mm mortar	0.50
130mm gun	0.70	51mm mortar	0.30
152mm gun-howitzer	0.74	81mm SP mortar	0.58
152mm gun	0.66	106.7mm mortar	0.54
203mm howitzer	0.62	106.7mm SP mortar	0.65
203mm SP gun 2S7	0.66	120mm mortar	0.56
82mm mortar	0.45	120mm SP mortar	0.71
82mm SP mortar Vasilek	0.60	110mm LARS rocket launcher	0.77
107mm mountain mortar	0.42	115mm MRL	0.77
120mm mortar	0.60		
160mm mortar	0.60		
240mm mortar	0.74		
240mm SP mortar 2S4	0.80		
30mm AGS-17	0.12		
122mm BM-21 MRL	0.87		
140mm BM-14 MRL	0.56		
240mm BM-24 MRL	0.70		
122mm BM-21 Grad-1	0.90		
220mm BM-27 MRL	0.95		
200mm BMD20 MRL	0.73		
132mm BM-13 Katyusha	0.40		
122mm BM-21B MRL	0.75		
140mm RPU-14 MRL	0.42		
Ground Forces and Aviation of the USSR		Armies of the Probable Enemy	
Nomenclature of Armament	Combat Potential	Nomenclature of Armament	Combat Potential
Antitank Weapons			
Konkurs AT-5 Spandrel	0.93	HOT	0.98
Fleyta AT-2 Swatter	0.95	TOW	0.95
Falanga-M	0.70	SS-12	0.80
Malyutka-P AT-3 Sagger	0.67	MILAN	0.78
Fagot AT-4 Spigot	0.62	SS-11B1	0.70
Malyutka AT-3 vehicle mount	0.60	SS-11SP	0.60
Malyutka AT-3PK	0.55	DRAGON	0.52
Falanga vehicle mount	0.50	ENTAC SP	0.48
Shmel AT-1 Snapper	0.31	VIGILANT	0.40
Shmel AT-1 vehicle mount	0.37	Cobra	0.40
T-12 100mm AT gun	0.65	SS-10	0.34
BS3 100mm AT gun	0.46	Jagdpanther 90mm SP gun	0.63
D-44 85mm AT gun	0.44	120mm recoilless rifle	0.23
ZIS-2 57mm AT gun	0.30	106mm recoilless rifle	0.28
B-10 82mm recoilless rifle	0.15	75mm recoilless rifle	0.20
SPG-9 73 MM recoiless gun	0.25	90mm AT rocket launcher	0.12
RPG-7	0.12	88.9mm shoulder-fired AT rocket	0.10
		66mm 4-barrel AT rocket launch	0.15
		66mm AT rocket launcher	0.05

Table 2. Combat potentials of large units					
Designation of Large Unit	Combat Potential of Rated Divisions	Total Combat Potential in Units of Armament	Designation of Large Unit	Combat Potential of Rated Divisions	Total Combat Potential in Units of Armament
Motorized Rifle Division, T-55, BMP	**1.00**	**652**	**US Infantry Division**	**0.86**	**564**
Motorized Rifle Division, T-64A, T-72, BMP	**1.18**	**766**	**US Mechanized Division**	**1.10**	**718**
Motorized Rifle Division, T-62, BMP	**1.04**	**680**	**US Armored Division**	**1.23**	**803**
Motorized Rifle Division, T-54B, BTR	**0.82**	**533**	**US Airborne Division**	**0.68**	**441**
Guards Motorized Rifle Division T-64A, BMP, SP Arty	**1.29**	**842**	**US Non-organic Division**	**0.72**	**468**
Guards Motorized Rifle Division T-62, BMP, SP Arty	**1.13**	**736**	**FRG Infantry Division**	**1.22**	**795**
Motorized Rifle Division T-64A, T-72, BTR	**1.05**	**684**	**FRG Motorized Infantry Division**	**1.30**	**849**
Motorized Rifle Division T-62, BTR	**0.92**	**599**	**FRG Tank Division**	**1.27**	**825**
Motorized Rifle Division T-62, BMP	**1.01**	**660**	**FRG Mountain Infantry Division**	**1.04**	**682**
Tank Division, T-64A, BMP	**1.22**	**793**	**UK Infantry Division**	**0.39**	**257**
Tank Division, T-62, BMP	**1.01**	**656**	**UK Armored Division**	**0.77**	**503**
Tank Division, T-72	**1.21**	**787**	**Belgian Mechanized Infantry Division**	**0.68**	**445**
Polish Motorized Division	**0.67**	**437**	**Danish Mechanized Infantry Division**	**0.92**	**605**
Polish Tank Division	**0.51**	**304**	**Netherlands Mechanized Infantry Division**	**0.94**	**614**
East German Motorized Rifle Division	**0.75**	**487**	**French Mechanized Division**	**0.23**	**152**
East German Tank Division	**0.72**	**466**	**French Infantry Division**	**0.23**	**152**
Czech Motorized Rifle Division	**0.75**	**490**	**French Alpine Infantry Division**	**0.32**	**208**
Czech Tank Division	**0.63**	**413**	**Canadian Separate Mechanized Battle Group**	**0.20**	**128**

Endnotes

1. V. I. Belyakov, “Соотношение Сил и Средств” [Correlation of Forces and Means], *Советская Военная Энциклопедия* [Soviet Military Encyclopedia], Volume 7 (Moscow: Voyenizdat, 1979), 445.

2. Michael Chichenski, “Soviet Correlation of Forces and Means” (class lecture, U.S. Army Russian Institute, Garmisch, Germany, 1982).

3. James K. Womack, “Soviet Correlation of Forces and Means: Quantifying Modern Operations” (master’s thesis, U.S. Army Command and General Staff College, Fort Leavenworth, KS, 1990), 41, https://apps.dtic.mil/dtic/tr/fulltext/u2/a227427.pdf.

4. Ibid., 11–12; and Jacob W. Kipp, *From Foresight to Forecasting: The Russian and Soviet Military Experience* (College Station, TX: Center for Strategic Technology, Texas A&M University, 1988), 18–19.

5. “Osipov’s most unique and important contribution is the explicit and systematic application to quantitative historical data of what, for his time, were fairly advanced formal statistical methods.” Robert L. Helmbold and Allan S. Rehm, translators’ notes to *Research Paper CAA-RP-91-2: The Influence of the Numerical Strength of Engaged Forces on their Casualties,* by M. Osipov, trans. Robert L. Helmbold and Allan S. Rehm (Bethesda, MD: Army Concepts Analysis Agency, 1991), ix, originally published in Russian as “The Influence of the Numerical Strength of Engaged Forces on their Casualties,” *Voenniy*

Sbornik [Military Collection] (June–October 1915). M. Osipov wrote a series of articles in the June to October 1915 editions of the Tsarist military journal *Voenniy Sbornik*. He used differential equations to model the combat losses of opposing sides based on raw historical data from 38 major battles from the Napoleonic Wars to the Russo-Japanese War. There is no trace of Osipov after the Russian Revolution. Most likely, he was Colonel Mikhail Pavlovich Osipov, a topographic engineer. Jacob S. Kipp, "Tracking Down Russia's Lanchester," *Journal of Slavic Military Studies* 17, no. 2 (2004): 257–269.

6. Frederick W. Lanchester (1868–1946) was an English mathematician and engineer who designed automobiles, postulated the theory of aerodynamics, and founded the science of operational research. He developed the Lanchester differential equations for calculating relative strengths of military forces.

7. Kipp, *From Foresight to Forecasting,* 87–89, in Womack, "Soviet Correlation of Forces and Means," 12–13.

8. Vitali Tsygichko, *Models is the System of Strategic Decisions in the USSR* (Riga: Lambert Academic Publishing, 2019), 13–14.

9. Ibid., 14–15.

10. Ibid., 15, 27.

11. Ibid., 28–29.

12. Ibid., 37.

13. Ibid., 47.

14. "Соотношение Сил и Средств" [Correlation of Forces and Means], *Военный Энциклопедический Словарь* [Military Encyclopedic Dictionary] (Moscow: Voyenizdat, 1983), 691.

15. John A. Battilega and Judith K. Grange, *The Military Applications of Modeling* (Washington, DC: U.S. Government Publishing Office, 1984), was the foundation document of the U.S. Operations Research/Systems Analysis (ORSA) effort. Allan S. Rehm and Pete Shugart were key researchers in the U.S. effort. British researcher Charles Blandy wrote the best English-language publication on the subject, Charles W. Blandy, *Calculating Combat Outcomes* (Sandhurst, UK: Soviet Studies Research Centre, 1993). Unfortunately, by the time it had cleared the hurdles of security review, it was February 1993. The Soviet Union had collapsed and Blandy's work has enjoyed a limited readership.

16. For a discussion of this concept, see Clint Reach, Vikram Kilamei, and Mark Cozad, *Russian Assessments and Applications of the Correlation of Forces and Means* (Santa Monica, CA: RAND, 2020), 39–45.

17. Memorandum for Director of Central Intelligence, "Combat Potentials of the Armament and Combat Equipment of the Ground Forces and Aviation of the USSR and the Armies of the Probable Enemy, and Table of the Combat Potentials of Large Units," 25 August 1980. This document was declassified from Top Secret to Unclassified and approved for release by the Historical Collection Division on 18 August 2012.

18. A. Ya. Vayner, *Тактические расчёты* [Tactical calculations] (Moscow: Voyenizdat, 1977) was the primary planning text for battalion and regimental staffs that lacked computer access.

19. Memorandum, "Combat Potentials."

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