ARL-SR-0423 ● JAN 2020

DEVCOM ARMY RESEARCH LABORATORY

An Extended Data Set for Explorations in Long-Range Forecasting of Military Technologies

by Alexander Kott

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED (From - To)
January 2020	Special Report	1 May–31 December 2019

4. TITLE AND SUBTITLE
An Extended Data Set for Explorations in Long-Range Forecasting of Military Technologies

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Alexander Kott

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army CCDC Army Research Laboratory
ATTN: FCDD-RLD
Adelphi, MD 20783

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-SR-0423

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
ORCID ID(s): Alexander Kott, https://orcid.org/0000-0003-1147-9726

14. ABSTRACT

This report documents an extension to a data set previously published as a part of the US Army Combat Capabilities Development Command Army Research Laboratory report ARL-SR-0417. The data were prepared by the author for exploratory investigations into the feasibility of long-range trend analysis in the properties of military technologies and were extracted primarily from widely available open sources. The time period ranges from 1100 CE to 2015. The types of military weapon systems considered in these data sets are selected classes of direct-fire ground-mobile systems, such as infantry small arms (ranging from longbows and crossbows to modern assault rifles), cannons, tanks, tank destroyers, and so on. The records in the data sets cover, for example, the year when a system first appeared, the muzzle velocity of the projectile, the effective range of the weapon, the mass of the system, the motive power of the system, and so on. The report contains a combined table of data—both those reported in ARL-SR-0417 as well as additional data—together with additional notes on the sources of the data.

15. SUBJECT TERMS
future-casting, technological forecasting, military technology, ground warfare, weapon systems, history of technology

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Alexander Kott
Unclassified	Unclassified	Unclassified	UU	100	19b. TELEPHONE NUMBER (Include area code) (301) 394-1507

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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Acknowledgments

The author thanks Carol Johnson of US Army Combat Capabilities Development Command Army Research Laboratory's Technical Publishing office who organized and edited my rough manuscript.

1. Introduction

This report should be seen as a continuation of an earlier report by the same author. In that earlier report, ARL-SR-0417 (Kott 2019a), I introduced a data set describing nearly 200 weapon systems that I called "mobile direct-fire systems" (MFS). These systems first appeared in the years between 1100 and 2015 CE. When referring to a "system", I include everything that is required for its mobility and ability to deliver effects on hostile targets. For example, a bowman system includes the bow, the human operator of the bow, and the necessary supply of arrows. Similarly, a field artillery cannon system also includes the crew, the horses, and the caisson.

The systems differ widely in many respects, but do have important common characteristics. All these systems are 1) ground mobile (i.e., commonly maneuvering on the ground during a battle) and 2) achieve their effects on hostile targets via the kinetic energy (KE) of their projectiles, delivered approximately along a line of sight at a relatively flat trajectory. This excludes, for example, medieval artillery, which remained generally static during a battle; heavy artillery that did not commonly maneuver in a ground engagement; indirect-fire artillery; and artillery and missile systems that use explosive shells.

Even with these restrictions, the resulting collection of systems is extremely diverse, including lightly armored bowmen; light and heavy armored horse-mounted archers; longbowmen; crossbowmen; foot soldiers with handgonnes and harquebuses; pistol-armed knights and reiters; musket-armed foot soldiers; soldiers with long rifles, Minie´-ball rifled muskets, early breechloaders, repeaters, or modern assault rifles; crews with machine guns; early modern artillery; pre-Napoleonic and Napoleonic artillery; early rifled and breech-loading artillery; WW1, WW2, and modern artillery; foot, horse, and vehicle-towed artillery; antitank towed artillery; assault guns; self-propelled antitank guns; tanks from WW1, WW2, and post-WW2; and "technicals".

This report adds the following to the earlier report ARL-SR-0417 (Kott 2019a):

- About 100 additional systems have been added, thereby expanding the original data set of MFS by about 50%.
- The additional data include two classes of weapons that were not considered in the earlier report: "technicals" (i.e., civilian vehicles equipped with heavy machine guns [HMGs] or automatic cannons, popular in certain military conflicts since 1970s) and crews with machine guns.
- A few corrections have been made to the data points published earlier.

For motivation and background of this work, the reader should consult the earlier report (Kott 2019a), as well Kott and Perconti (2018), Kott et al. (2019), and Kott (2019b).

This report is organized as follows. Section 2 discusses the limitations and disclaimers associated with the data sets documented here. Section 3 presents data and notes on sources pertaining to MFS. Finally, Section 4 offers a few conclusions.

2. Limitations, Sources, and Disclaimers

The data sets presented in this report are limited in a number of ways. For a full discussion of limitations and disclaimers, please see ARL-SR-0417 (Kott 2019a).

Here I would only reiterate that the sources used for this report are inevitably uneven in quality and degree of authority. In a number of cases, assumptions and estimates are quite crude, and should be revisited in future work. As such, the data in this report should be used with caution and certainly not for the purposes of obtaining authoritative data for any individual system. Still, I assess that the data from different sources are generally consistent within any given historical period and portray plausible trends over time. This should give a researcher a degree of confidence in the data sets. The value of these data is not in individual data points but in the data ensemble. To put it differently, the value is not in an individual pixel but in the overall picture.

To illustrate the last point, consider Fig. 1, which shows how the data presented in this report follow a remarkable regularity. For detailed discussion of this figure, see Kott (2019b), especially Fig. 6 of that paper.

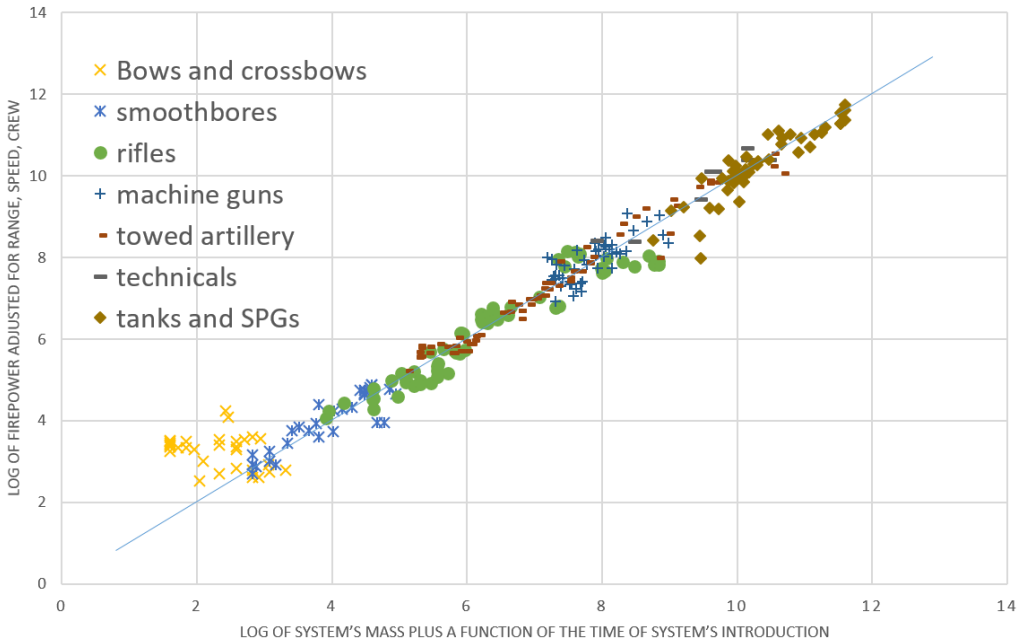

Fig. 1 Firepower (adjusted for system's speed, range, and crew) as a function of mass and year of introduction. Nearly 300 mobile direct-fire systems of the years 1100–2015 all fall approximately on the same curve. Vertical axis: log(MuzzleKE[J]*RateOfFire[rpm]) + 1.179*log(Range[m]) + 0.974*log(Speed[kph]) - 1.133*log(Crew) - 1.93. Horizontal axis: log(Mass[kg]) + k*(Year-1832) + 3.258, where k=0.0049 before the year 1832 and 0.02 after. (Details in Kott A. Toward universal laws of technology evolution: modeling multi-century advances in mobile direct-fire systems. The Journal of Defense Modeling and Simulation. 2019.)

3. Data Set of Ground-Mobile, Direct-Fire Weapon Systems

The data in this section describe nearly 300 of what I call ground-mobile (i.e., commonly maneuvering on the ground during a battle) weapon systems that achieve their effects on hostile targets via the KE of their projectiles, delivered at line of sight along a relatively flat trajectory. This excludes, for example, medieval artillery, which remained generally static during a battle; heavy artillery that is not commonly used in a ground maneuver during an engagement; indirect-fire artillery; or use of explosive shells; and so on.

The first column of the data table (Table 1 in Section 3.1) describes the system. An infantryman with a weapon is a type of a MFS. Acronyms in this column are as follows: LAI refers to light armored infantry, LNI refers to light infantry without armor, and MAI refers to modern infantry that uses body armor. The second column provides references to notes found in Section 4 of ARL-SR-4017 (Kott 2019a). The third column provides references to notes found either in Section 5 of ARL-SR-4017 or those in this report. In the third column, each note number is preceded by the letters "MFS" to distinguish this set of notes from the notes in Section 4 of ARL-SR-4017.

Note numbers are not necessarily consecutive; there are gaps in the number sequence.

The remainder of columns in Table 1 contain the following data:

- **Year of Introduction** is the approximate year in which the weapon was introduced or designed. I limit the period under consideration to 1100 CE to 2015. In most cases, sources exist that report at least the approximate date of the weapon's design or introduction into service, but in some cases, I had to resort to assumptions.
- **Projectile Mass** is the mass of the projectile issued by the weapon. I include this in this data set for several reasons. It influences the KE of the projectile, and thereby, the ability to disable the adversary. A higher mass also reduces the impact of wind on the trajectory of the projectile, and thereby, increases the accuracy of the weapon. However, a higher mass of a projectile also has undesirable ramifications; for example, it reduces the number of projectiles (or rounds) that the infantryman can carry into a battle. It also increases the recoil (i.e., the backward blow that a gun delivers to the body of the shooter when the gun discharges). These are merely examples of the issues related to the mass of a projectile; in general, many complex dependencies exist. The data for the mass of projectiles (arrows, bolts, bullets) are typically available and are largely consistent.
- **Muzzle Velocity** is the projectile velocity at the moment of separation from the weapon (i.e., the arrow velocity as it exits the bow or the bullet velocity when it exits the muzzle). In most cases, sources exist to provide these data. In some cases, the KE and the mass of the projectile were known, and the velocity was calculated from these data. The velocity of the projectile is an important characteristic of a weapon. It influences the amount of KE that is available to incapacitate the adversary. It also determines, in part, how flat the trajectory of the projectile is, and thereby, the potential accuracy of the weapon. For the purposes of this data set, I do not consider so-called

"terminal effects"—the characteristics and behavior of the projectile as it interacts with the target. An attempt to consider terminal effects explicitly would require a level of detail that goes far beyond what is appropriate for trend-based forecasting.

- **Protection** here is of a rather qualitative nature. It is taken as the muzzle kinetic energy (ME; in joules) of a weapon that is considered in the literature as reasonably effective in defeating the system. For example, the protection of a Panzer IV of the 1943 version is considered in literature as reasonably adequate (although certainly not invulnerable) against the contemporary T-34. In other words, the Panzer IV "meets its match" in the T-34. Thus, I take the ME of the T-34 gun as roughly indicative of the level of protection of the Panzer IV. Needless to say, this is a very approximate and nearly qualitative rather than quantitative approach.

- **Effective Range** is the maximum effective range (i.e., the distance at which an infantryman can fire the weapon with an acceptable probability of hitting and disabling the targeted adversary). This is another very important characteristic of a weapon. By maximizing this distance, the infantryman increases the probability of their own survival while fulfilling their mission of defeating the adversary. In the US military, the official definitions of maximum effective range are not particularly clear or consistent. For the purposes of this data set, I recognize the weaknesses of existing definitions and interpret them to imply that a typical infantryman in typical operational conditions, when firing the weapon from a distance D, should have 50% probability of hitting the target (presumably, a person-sized target) and disabling the adversary. For modern weapons, effective range data are available from a variety of sources, including official government sources, although disagreements exist regarding their accuracy. For weapons introduced prior to the 20th century, the data are difficult to find and are widely inconsistent.

- **Rate of Fire** is the maximum rate of fire (i.e., the maximum number of projectiles per minute that an infantryman can fire from the weapon). For many weapons, such as bows or muskets, the rate of fire is on the order of 1–10 per minute, including the time required to reload and re-aim the weapon. For fully automatic weapons, this rate (called the cyclic rate of fire) may exceed 1000 per minute, although prolonged firing at that rate may overheat and destroy the weapon. Rate of fire is an important characteristic of a weapon for a number of reasons. For example, it enables the infantryman to maximize the chances of hitting the adversary when they are visible for a short time. An alternative would be to use the sustained rate of

fire, that is, the rate that at which projectiles can be fired without overheating the weapon (e.g., in case of an automatic rifle) or overtiring the shooter (e.g., in case of a longbow), but I elected to focus on the maximum rate of fire. The data are generally available, although not always consistent for historical weapons.

- **System Mass** includes everything that is directly required for that system to maneuver and operate tactically on the battlefield. In the case of an infantryman, it includes the mass of the person's body, the armor, and typical equipment, as well as the weight of the weapon(s) and ammunition. In the case of the cavalryman, the mass of the horse is included. In case of a towed cannon, the mass of the limber, ready ammunition, horses, and crew are included; caissons with additional ammunition are seen here as part of logistic support and are not included.
- **System Motive Power** is the power directly available to move the system on the battlefield. In the case of an infantryman, this is typically about 0.1 hp, the representative power of a human. For horse-towed artillery, this includes the power of the horses and the crew. For modern systems, it is the net engine power of the platform or the towing truck.
- **Crew** is the number of personnel directly serving the system during the engagement. It ranges from 1 in the case of an infantry or cavalryman, to as many as 15 in the case of an artillery piece.
- **Offroad Speed** is rather approximate and characterizes the speed with which the system can maneuver on the broken terrain of a battlefield for a relatively prolonged time as opposed to a short sprint.

3.1 Table of Data

Table 1 provides the data set for ground-mobile, direct-fire weapons.

Table 1 Data set of ground-mobile, direct-fire weapon systems

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Bows	LAI equipped with…	Byzantine bow (1)	45a	MFS011a, MFS023a	1100	0.032	75.3	160	75	5	85	0.1	1	3
	Cataphract	Byzantine bow		MFS010a	1100	0.032	75.3	200	75	5	620	1.1	1	15
	LAI	Byzantine bow (2)	45b	MFS011a, MFS023a	1100	0.06	55	160	75	5	85	0.1	1	3
	LAI	bow	46a	MFS011a, MFS023a	1100	0.0358	59.8	160	75	5	85	0.1	1	3
	LAI	longbow	76, 76d	MFS011a, MFS023a	1100	0.0536	66	160	75	5	85	0.1	1	3
	LAI	longbow	8, 76 (p. 48)	MFS011a, MFS023a	1100	0.102	47.23	160	75	5	85	0.1	1	3
	LAI	longbow	76a	MFS011a, MFS023a	1100	0.042	68.7	160	75	5	85	0.1	1	3
	LAI	longbow	76, 76d	MFS011a, MFS023a	1150	0.0578	62.5	160	75	5	85	0.1	1	3
	LAI	Turkish warbow	5	MFS011a, MFS023a	1100	0.1001	40.01	160	75	5	85	0.1	1	3
	Turkish horse archer	Turkish warbow	5	MFS011a, MFS023a	1100	0.1001	40.01	160	75	5	570	1.1	1	25

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Bows	LAI	Turkish warbow	5	MFS011a, MFS023a	1125	0.069	47.6	160	75	5	85	0.1	1	3
	LAI	Turkish warbow	5	MFS011a, MFS023a	1150	0.0478	56.4	160	75	5	85	0.1	1	3
	LAI	Turkish warbow	5	MFS011a, MFS023a	1175	0.0337	65.	160	75	5	85	0.1	1	3
	LAI	longbow	76, 76d	MFS011a, MFS023a	1250	0.0744	57.5	160	75	5	85	0.1	1	3
	LAI	longbow	51a	MFS011a, MFS023a	1250	0.13	37.4	160	75	5	85	0.1	1	3
	LAI	longbow	51b	MFS011a, MFS023a	1300	0.115	44.5	160	75	5	85	0.1	1	3
	LAI	yew longbow	52, p. 918-919	MFS011a, MFS023a	1300	0.05	53	160	75	5	85	0.1	1	3
	LAI	yew longbow	52, p. 918-919	MFS011a, MFS023a	1300	0.09	43	160	75	5	85	0.1	1	3
	LAI	longbow	76, 76d	MFS011a, MFS023a	1325	0.0866	53.5	160	75	5	85	0.1	1	3
	LAI	longbow	76a	MFS011a, MFS023a	1350	0.108	52	160	75	5	85	0.1	1	3
	LAI	longbow	76, 76d	MFS011a, MFS023a	1375	0.0959	52.5	160	75	5	85	0.1	1	3

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Crossbows	LAI	crossbow d-w 600 lb	3, 3a	MFS011a, MFS023a	1190	0.06	44.6	160	75	1	85	0.1	1	3
	LAI	crossbow	52, p. 920	MFS011a, MFS023a	1200	0.1	43	160	75	2	85	0.1	1	3
	LAI	crossbow	76b	MFS011a, MFS023a	1250	0.06	39.	160	75	2	85	0.1	1	3
	LAI	crossbow	51c	MFS011a, MFS023a	1300	0.06	44.7	160	75	2	85	0.1	1	3
	LAI	crossbow d-w 750 lb	3, 3a	MFS011a, MFS023a	1350	0.1	38.64	160	75	1	85	0.1	1	3
	LAI	crossbow, 1000 lb	82	MFS011a, MFS023a	1350	0.096	47.88	160	75	1	85	0.1	1	3
	LAI	crossbow, 740 lb	4	MFS011a, MFS023a	1370	0.0354	64.3	160	75	1	85	0.1	1	3
	LAI	crossbow d-w 1500 lb	3, 3a	MFS011a, MFS023a	1399	0.1	54.68	160	75	1	85	0.1	1	3
	LAI	crossbow, 1090 lb	3, 3a	MFS011a, MFS023a	1450	0.1	46.62	160	75	1	85	0.1	1	3
	LAI	crossbow	52, p. 919-920	MFS011a, MFS023a	1400	0.08	70	160	75	0.5	85	0.1	1	3

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LAI	Loshult handgonne	51 p. 9	MFS011a, MFS023a	1350	0.184	142	160	25	0.5	85	0.1	1	3
	LAI	handgonne	51 p. 69	MFS011a, MFS023a	1350	0.041	179	160	25	0.5	85	0.1	1	3
	LAI	handgonne	52 p. 921-922	MFS011a, MFS023a	1350	0.0385	239	160	25	0.5	85	0.1	1	3
	LAI	handgonne	26	MFS011a, MFS023a	1362	0.05	200	160	25	0.5	85	0.1	1	3
	LAI	handgonne	52 p. 921-922	MFS011a, MFS023a	1400	0.04	255	160	25	0.5	85	0.1	1	3
	LAI	handgonne	52 p. 921-922	MFS011a, MFS023a	1400	0.039	343	160	25	0.5	85	0.1	1	3
	LAI	Hussite gun	52 p. 921	MFS011a, MFS023a	1420	0.0352	250	160	25	0.5	85	0.1	1	3
	LAI	arquebus	42	MFS011a, MFS023a	1455	0.0277	240	160	50	1	85	0.1	1	3
	LAI	harquebus	51 p. 26-27	MFS011a, MFS023a	1470	0.016	450	160	50	1	85	0.1	1	3

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LAI	handgonne	51 p. 69	MFS011a, MFS023a	1490	0.041	469	160	25	1	85	0.1	1	3
	LAI	matchlock harquebus	51 p. 75	MFS011a, MFS023a	1520	0.0122	521	160	50	1	85	0.1	1	3
	LAI	tanegashima	81	MFS011a, MFS023a	1543	0.0374	366	160	50	1	85	0.1	1	3
	LAI	arquebus	76, p. 398	MFS011a, MFS023a	1550	0.02	340	160	50	1	85	0.1	1	3
	LAI	musket	76, p. 398	MFS011a, MFS023a	1550	0.038	482	160	75	1	85	0.1	1	3
	Knight, 16c	pistol		MFS002, MFS039, MFS043, MFS057	1550	0.00965	385	300	10	5	620	1.1	1	15
	LAI	heavy musket, rifled G284	47	MFS011a, MFS023a, MFS125	1571	0.0383	482	160	75	1	85	0.1	2	3
	Reiter	pistol, sword		MFS002, MFS039, MFS043, MFS047, MFS057	1575	0.00965	385	250	10	5	600	1.1	1	15

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LAI	heavy musket, rifled G358	47	MFS011a, MFS023a, MFS125	1580	0.0491	533	160	75	1	85	0.1	2	3
	LAI	wheellock RG117	47	MFS011a, MFS023a	1593	0.0108	427	160	75	1	85	0.1	1	3
	LAI	wheellock RG33	47	MFS011a, MFS023a	1595	0.03	456	160	75	1	85	0.1	1	3
	LAI	matchlock LG1514	47	MFS011a, MFS023a	1620	0.0174	449	160	75	2	85	0.1	1	3
	LAI	wheellock RG272 rifled	47	MFS011a, MFS023a	1625	0.0321	392	160	75	2	85	0.1	1	3
	LAI	musket	46, p. 70-71	MFS011a, MFS023a	1650	0.041	306	160	75	2	85	0.1	1	3
	LNI	flintlock STG1318	47	MFS011a, MFS023a	1686	0.0309	494	80	75	2	75	0.1	1	4
	LNI	musket	12	MFS011a, MFS023a	1700	0.0198	550	80	75	2	75	0.1	1	4
	LNI	flintlock musket STG1287	47	MFS011a, MFS023a	1700	0.0275	474	80	75	2	75	0.1	1	4
	LNI	flintlock STG1316	47	MFS011a, MFS023a	1700	0.0321	451	80	75	2	75	0.1	1	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LNI	flintlock STG1317	47	MFS011a, MFS023a	1700	0.0343	467	80	75	2	75	0.1	1	4
	LNI	flintlock E28	47	MFS011a, MFS023a	1715	0.0299	543	80	75	2	75	0.1	1	4
	LNI	Charleville	25, 71, 72	MFS011a, MFS023a	1717	0.0243	450	80	75	3	75	0.1	1	4
	LNI	Brown Bess	16, 14, 48, 71, 72	MFS011a, MFS023a	1722	0.0329	450	80	75	3	75	0.1	1	4
	LNI	Brown Bess	48, 71, 72	MFS011a, MFS023a	1722	0.0321	457	80	75	3	75	0.1	1	4
	LNI	long rifle - 1	19	MFS011a, MFS023a	1725	0.0107	366	80	200	2	75	0.1	1	4
	LNI	long rifle - 2	19	MFS011a, MFS023a	1725	0.0062	488	80	200	2	75	0.1	1	4
	LNI	Kentucky rifle	79, p. 181	MFS011a, MFS023a	1725	0.00828	566	80	200	2	75	0.1	1	4
	LNI	Pennsylvania rifle	79, p. 242	MFS011a, MFS023a	1725	0.00291	532	80	200	2	75	0.1	1	4
	LNI	flintlock musket STG1288	47	MFS011a, MFS023a	1775	0.026	455	80	75	3	75	0.1	1	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LNI	Jaeger rifle	77	MFS011a, MFS023a	1780	0.0188	471	80	200	2	75	0.1	1	4
	LNI	Springfield M1795	60, 70	MFS011a, MFS023a	1795	0.0298	370	80	75	3	75	0.1	1	4
	LNI	Baker rifle	66, 72	MFS011a, MFS023a	1800	0.0226	315	80	200	1.5	75	0.1	1	4
	LNI	M1819 Hall rifle	60	MFS011a, MFS023a	1811	0.014	330	80	200	8	75	0.1	1	4
	LNI	Hawken rifle, cal. 53	79, p. 171	MFS011a, MFS023a	1823	0.0136	571	80	200	2	75	0.1	1	4
	LNI	Hawken rifle, cal. 50	79, p. 180, p. 187	MFS011a, MFS023a	1823	0.0114	569	80	200	2	75	0.1	1	4
	LNI	Dreyse needle gun	60	MFS011a, MFS023a	1836	0.025	305	80	200	6	75	0.1	1	4
	LNI	Brunswick rifle	60, 67, 69	MFS011a, MFS023a	1836	0.0312	311	80	200	2	75	0.1	1	4
	LNI	Mississippi rifle M1841	60	MFS011a, MFS023a	1841	0.032	360	80	200	2	75	0.1	1	4
	LNI	1841 Mississippi rifle	79, p. 236	MFS011a, MFS023a	1841	0.0342	315	80	200	2	75	0.1	1	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LNI	Sharps rifle	60	MFS011a, MFS023a	1848	0.0307	370	80	200	10	75	0.1	1	4
	LNI	Fusil Minié	60, 68	MFS011a, MFS023a	1849	0.0324	270	80	200	3	75	0.1	1	4
	LNI	Enfield 1853 rifled musket	60	MFS011a, MFS023a	1853	0.03235	270	80	270	3	75	0.1	1	4
	LNI	Enfield 1853 rifled musket	69	MFS011a, MFS023a	1853	0.0451	277	80	270	3	75	0.1	1	4
	LNI	Enfield 1853 rifle	79, p. 228	MFS011a, MFS023a	1853	0.0326	364	80	270	3	75	0.1	1	4
	LNI	Whitworth rifle	79, 60	MFS011a, MFS023a	1854	0.03171	398	80	270	3	75	0.1	1	4
	LNI	Chassepot	60	MFS011a, MFS023a	1858	0.025	410	80	270	8	75	0.1	1	4
	LNI	Springfield 1861	17	MFS011a, MFS023a	1861	0.0188	390	80	270	3	75	0.1	1	4
	Cavalry	Spencer carbine	60	MFS011a, MFS023a	1863	0.023	370	80	270	20	590	1.1	1	25
	LNI	Winchester	21	MFS011a, MFS023a	1866	0.01308	343	80	270	20	75	0.1	1	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LNI	Werndl-Holub	53	MFS011a, MFS023a	1867	0.024	439	80	270	7	75	0.1	1	4
	LNI	Vetterli	60	MFS011a, MFS023a	1867	0.022	427.5	80	270	7	75	0.1	1	4
	LNI	Berdan	23	MFS011a, MFS023a	1870	0.0197	437	80	270	7	75	0.1	1	4
	LNI	Martini-Henri	2, 53	MFS011a, MFS023a	1871	0.031	396.5	80	370	12	75	0.1	1	4
	LNI	Mauser 1871	53	MFS011a, MFS023a	1871	0.025	440	80	370	12	75	0.1	1	4
	LNI	Springfield 1873	53	MFS011a, MFS023a	1873	0.0325	410	80	270	15	75	0.1	1	4
	LNI	Gras rifle	22	MFS011a, MFS023a	1874	0.0249	455	80	250	7	75	0.1	1	4
	LNI	Lebel rifle	60	MFS011a, MFS023a	1886	0.015	610	80	400	21	75	0.1	1	4
	LNI	Austrian Manlicher	2	MFS011a, MFS023a	1886	0.0157	620	80	500	20	75	0.1	1	4
	LNI	Lee-Metford	2, 60	MFS011a, MFS023a	1888	0.0116	564	80	500	20	75	0.1	1	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LNI	Rubin	2	MFS011a, MFS023a	1889	0.0139	600	80	500	15	75	0.1	1	4
	LNI	Belgian Mauser	2	MFS011a, MFS023a	1889	0.0141	620	80	500	15	75	0.1	1	4
	LNI	Mosin-Nagant	60	MFS011a, MFS023a	1891	0.0097	865	80	500	15	75	0.1	1	4
	LNI	Mosin-Nagant	2	MFS011a, MFS023a	1891	0.0138	587	80	500	15	75	0.1	1	4
	LNI	Carcano	2	MFS011a, MFS023a	1891	0.0105	730	80	500	15	75	0.1	1	4
	LNI	Lee-Enfield	24	MFS011a, MFS023a	1895	0.0122	744	80	500	25	75	0.1	1	4
	LNI	Mannlicher M1895	60	MFS011a, MFS023a	1895	0.016	620	80	500	20	75	0.1	1	4
	LNI	Arisaka Mauser	2	MFS011a, MFS023a	1887	0.0105	697	80	500	15	75	0.1	1	4
	LNI	Mauser 98	60	MFS011a, MFS023a	1898	0.0146	639	80	500	15	75	0.1	1	4
	LNI	Mauser w/ Spitzgeschoss	2	MFS011a, MFS023a	1905	0.0099	879	80	500	15	80	0.1	1	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LNI	M1 Garand	60	MFS011a, MFS023a	1928	0.011	853	80	500	40	80	0.1	1	4
	LNI	SVT-40	60	MFS011a, MFS023a	1940	0.0097	835	80	500	25	80	0.1	1	4
	LNI	Sturmgewehr 44	60	MFS011a, MFS023a	1942	0.0081	685	80	600	550	80	0.1	1	4
	LNI	Gewehr 43	60	MFS011a, MFS023a	1943	0.0128	776	80	500	25	80	0.1	1	4
	LNI	AK-47	29b	MFS011a, MFS023a	1947	0.00793	710	80	380	600	80	0.1	1	4
	LNI	M-14	39	MFS011a, MFS023a	1949	0.00959	830	80	460	700	80	0.1	1	4
	LNI	G3	60	MFS011a, MFS023a	1955	0.011	800	80	500	550	80	0.1	1	4
	LNI	M-16	29b	MFS011a, MFS023a	1957	0.00357	990	80	550	800	80	0.1	1	4
	LNI	FN FAL	47	MFS011a, MFS023a	1958	0.00945	835	80	400	700	80	0.1	1	4
	LNI	AK-74	60	MFS011a, MFS023a	1974	0.00342	880	80	500	600	80	0.1	1	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System		Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Infantry firearm	LNI	SA 80	60	MFS011a, MFS023a	1975	0.00356	940	80	300	700	80	0.1	1	4
	LNI	Steyr	47	MFS011a, MFS023a	1977	0.0036	990	80	300	700	80	0.1	1	4
	LNI	FA MAS	35	MFS011a, MFS023a	1978	0.0035597	993	80	400	1000	80	0.1	1	4
	LNI	G36	60	MFS011a, MFS023a	1990	0.00356	920	1000	500	750	80	0.1	1	4
	MAI	M-4	40	MFS011a, MFS023a	1993	0.0040741	900	1000	500	700	105	0.1	1	3
	MAI	FN SCAR-H	60	MFS011a, MFS023a	2004	0.011	714	1000	600	600	105	0.1	1	3
	MAI	M-27	41	MFS011a, MFS023a	2008	0.0040741	900	2000	550	700	105	0.1	1	3
	MAI	AK-12	60	MFS011a, MFS023a	2011	0.00362	900	2000	600	700	105	0.1	1	3
	MAI	AK-15	60	MFS011a, MFS023a	2011	0.008	715	2000	550	700	105	0.1	1	3
Tanks	Mark IV			MFS058	1917	2.7	411	4000	1500	50	32000	105	8	5
	FT tank			MFS060	1917	0.67	600	15000	1500	15	6500	39	2	5

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Tanks	A7V		MFS136	1917	2.7	411	120000	1500	25	33000	200	18	7
	Vickers 6-ton tank		MFS061	1928	1.47	560	30000	1500	20	7300	98	3	17
	T-26 tank		MFS062	1931	1.43	760	4000	1500	15	9600	90	3	16
	Char B1 bis		MFS063	1934	1.7	855	537000	1000	15	28000	272	4	21
	SOMUA S35		MFS064	1935	1.7	855	270000	1000	15	19200	190	3	16
	KV-1 tank		MFS067	1939	6.5	680	2000000	1500	10	45000	600	5	16
	T-34 of 1941		MFS065	1940	6.5	680	676000	1500	10	29200	500	4	40
	M4A2 Sherman		MFS218	1942	6.74	609	1500000	2000	20	31800	375	5	20
	Tiger I		MFS074	1941	10.2	773	6000000	2000	15	57000	700	5	20
	T-34/85		MFS066	1943	9.2	792	2000000	2000	10	32000	500	5	20
	Panzer IV		MFS068	1943	4.1	990	2000000	2000	10	25000	296	5	16
	IS-2 tank		MFS069	1943	25	804	4660000	2000	5	46000	600	4	20
	Sherman Firefly		MFS221	1944	7.7	870	1500000	2000	10	32600	370	4	16
	Panther		MFS073	1943	7.2	935	2400000	1600	10	44800	690	5	30

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Tanks	Tiger II		MFS075	1943	7.3	1130	8000000	2500	15	68500	700	5	15
	M4A3(76) Sherman		MFS219	1944	6.99	780	2000000	2000	20	33600	450	5	20.8
	M26 Pershing		MFS072	1944	10.9	1200	3140000	2000	8	41700	450	5	8
	Centurion tank		MFS087	1946	5.8	1478	4660000	2000	10	52000	650	4	17
	T-54		MFS092	1949	15.6	1000	7848000	2000	6	36000	500	4	35
	M48 Patton		MFS090, MFS220	1953	10.9	1200	7800000	2000	8	45000	650	4	21
	M60		MFS091	1960	6.12	1490	7800000	2500	10	46000	750	4	16
	T-64		MFS093	1964	7.05	1750	6335000	3000	8	38000	700	3	30
	Chieftain tank		MFS088	1965	7.6	1370	7800000	3000	10	56000	750	4	30
	Strv 103B (aka S-tank)		MFS138	1971	7.6	1370	7800000	3000	15	39700	490	3	30
	T-72 tank		MFS079	1972	3.9	1785	6335000	3000	8	42500	780	3	45
	T-80		MFS094	1976	4.85	1715	7848000	3000	8	46000	1250	3	48
	M1 Abrams		MFS080	1979	6.12	1490	11421000	2500	6	54000	1500	4	40
	Challenger 1		MFS089	1982	4	1740	11421000	3000	10	70000	1200	4	30

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Tanks	M1A1 Abrams		MFS095	1986	4.85	1700	11421000	4000	8	67600	1500	4	48
	Challenger 2		MFS139	1989	4.85	1715	12000000	4000	10	75000	1200	4	40
	Leopard 2A6		MFS137	2007	8.35	1750	11421000	4000	8	62300	1479	4	48
	Leopard 2A6, v2		MFS137	2007	11	2050	11421000	4000	8	62300	1479	4	48
	Leopard 2A6, v3		MFS137, MFS156	2007	8.8	1700	11421000	4000	8	62300	1479	4	48
	T-14 Armata		MFS114	2016	8.35	1800	12000000	3000	10	48000	1500	3	45
	T-14 Armata v2		MFS114	2016	11	2050	12000000	3000	10	48000	1500	3	45
	T-14 Armata v3		MFS114, MFS156	2016	9.41	1800	12000000	4700	12	48000	1500	3	45
Self-propelled guns	Marder III		MFS104	1942	4.05	990	15000	1800	14	10670	148	4	20
	Sturmgeschütz III		MFS105	1940	4.1	990	1502000	1800	14	23900	296	4	20
	Jagdpanzer IV		MFS106	1943	4.75	1130	1502000	3000	14	25800	296	4	20

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Self-propelled guns	M36 Tank Destroyer		MFS220	1944	10.9	840	1500000	2000	8	28539	450	5	20.8
	SU-85		MFS108	1943	9.2	792	1000000	2500	10	29600	493	4	20
	SU-100		MFS109	1944	15.6	895	1500000	3000	5	31600	500	4	20
	BMPT Terminator		MFS157	2002	0.4	960	7000000	4000	600	47000	780	5	45
	2S25 Sprut-SD		MFS112	2005	8.1	1650	89000	2000	7	18000	510	3	45
Towed guns	Culverin Moyane 2-pdr		MFS152	1550	0.9	344	80	400	1	3400	4.6	6	5
	Falcon 1-pdr		MFS152	1550	0.45	344	80	300	1	2450	3.3	3	5
	Falconet 3/4-pdr		MFS152	1550	0.339	344	80	200	1	1700	2.3	3	5
	early-to-mid-1600s saker		MFS129, MFS216	1625	4.077	344	80	500	1	7140	9.2	12	5
	early-to-mid-1600s minion		MFS128, MFS216	1625	2.718	344	80	450	1	5180	7	10	5
	early-to-mid-1600s falcon		MFS127, MFS216	1625	1.359	344	80	400	1	3540	4.6	6	5

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Towed guns	Saker in Battle of Cheriton		MFS145, MFS146, MFS216	1644	2.4	344	80	518	1	5700	7	10	5
	Culverin 15-pdr		MFS152	1640	6.79	344	80	414	1	7005	9.5	15	5
	Demi-culverin 9-pdr		MFS152	1640	4.07	344	80	360	1	5370	7.3	13	5
	Saker 5-pdr		MFS152	1640	2.26	344	80	324	1	3670	5	10	5
	Minion 4-pdr		MFS152	1640	1.81	344	80	300	1	2786	3.8	8	5
	Falcon 2-pdr		MFS152	1640	0.9	344	80	288	1	951	1.3	3	5
	Falconet 1-pdr		MFS152	1640	0.45	344	80	270	1	884	1.2	2	5
	Robinet 3/4-pdr		MFS152	1640	0.339	344	80	270	1	884	1.2	2	5
	Saker		MFS156	1645	2.37	344	80	320	1	4420	6	10	5
	Minion		MFS156	1645	1.812	344	80	300	1	2786	3.8	8	5
	Falcon		MFS156	1645	1.01	344	80	290	1	1700	2.3	3	5
	Falconet		MFS156	1645	0.566	344	80	270	1	884	1.2	2	5
	Robinet		MFS156	1645	0.339	344	80	270	1	884	1.2	2	5

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Towed guns	Regimental Gun of mid-1600s		MFS126	1650	1.359	344	80	200	1	1150	1.3	3	5
	French Saker		MFS156	1666	2.718	344	80	400	1	3670	5	10	5
	French Sixteenth		MFS156	1666	1.359	344	80	400	1	2518	3.4	4	5
	French Thirty-second		MFS156	1666	0.6795	344	80	350	1	1701	2.3	3	5
	pre-Gribeauval, Austrian 12-pounder		MFS130	1740	5.436	344	80	600	2	9350	11.5	15	5
	pre-Gribeauval, Austrian 12-pounder v2		MFS130	1740	5.43	437	80	600	2	9350	11.5	15	5
	Prussian 6-pdr (HA)		MFS152	1760	2.718	390	80	600	2	5237	7.1	11	15
	Canon de 8 Gribeauval		MFS096, MFS122	1765	3.89	390	80	800	2	4731	5.3	13	5
	Light 6-pdr		MFS144, MFS096	1776	2.71	390	80	800	2	3555	5	10	5

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Towed guns	Canon de 8 Gribeauval (HA)		MFS096a, MFS122	1790	3.89	390	80	800	2	9911	15.5	15	15
	Canon de 12 Gribeauval		MFS098	1765	5.88	390	80	900	2	6323	7.5	15	5
	Canon de 12 Gribeauval (HA)		MFS098a	1790	5.88	390	80	900	2	11503	17.7	17	15
	Canon de 4 Gribeauval		MFS099	1765	1.95	390	80	700	2.5	3684	4.8	8	5
	Canon de 4 Gribeauval (HA)		MFS099a	1790	1.95	390	80	700	2.5	8864	15	10	15
	British 1790 12-pdr		MFS132	1790	5.43	440	80	900	2	6714	7.3	13	5
	British 1790 12-pdr (HA)		MFS132a	1790	5.43	440	80	900	2	11894	17.5	15	15
	British 1805 9-pdr		MFS131	1805	4.07	440	80	800	2	6200	7.2	12	5
	British 1805 9-pdr (HA)		MFS131a	1805	4.07	440	80	800	2	11380	17.4	14	15

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Towed guns	French AnXI 12-pdr		MFS133	1808	5.436	440	80	900	2	6337	7.3	13	5
	French AnXI 12-pdr (HA)		MFS133a	1808	5.436	440	80	900	2	11517	17.5	15	15
	French AnXI 6-pdr		MFS134	1808	2.718	440	80	700	2	4400	5	10	5
	French AnXI 6-pdr (HA)		MFS134a	1808	2.718	440	80	700	2	9580	15.2	12	15
	Griffen 3-inch Ordnance Rifle		MFS135	1854	2.718	460	80	1800	2	4236	4.8	8	5
	Griffen 3-inch Ordnance Rifle (HA)		MFS135a	1854	2.718	460	80	1800	2	9416	15	10	15
	Napoleon 1857 gun		MFS077, MFS052, MFS144	1857	5.57	457	80	1200	2	5550	6.8	8	5
	Napoleon 1857 gun (HA)		MFS077a	1857	5.57	457	80	1200	2	10730	17	8	15
	Prussian C/61		MFS124	1857	6.75	331	80	1500	3	5500	6.8	8	5

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Towed guns	Prussian C/61 (HA)		MFS124a	1857	6.75	331	80	1500	3	10680	17	10	15
	RBL 12-pdr 8 cwt Armstrong gun		MFS100	1859	5.44	378	80	3100	3	3610	4.8	8	5
	RBL 12-pdr 8 cwt Armstrong gun (HA)		MFS100a	1859	5.44	378	80	3100	3	8790	15	10	15
	Parrott 10-pdr rifle		MFS078, MFS144	1860	10	369	80	1700	2	5400	8.8	8	5
	Parrott 10 pdr rifle (HA)		MFS078a	1860	10	369	80	1700	2	10580	19	10	15
	German 96 m/A 77mm		MFS162	1896	6.8	465	3000	1800	10	4920	6.6	6	5
	Canon de 75 modèle 1897		MFS101	1897	7.25	500	3000	1800	15	5444	6.6	6	5
	British QF 13-pdr, horse artil.		MFS027, MFS144	1904	5.7	511	3000	1800	15	8428	12.6	6	15
	British QF 13-pdr, field artil.		MFS027, MFS144, MFS161	1904	8.4	492	3000	1800	20	6000	6.6	6	5

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Towed guns	3.7-cm Pak 36 antitank gun		MFS141	1933	0.685	745	3000	500	13	3567	38	5	15
	47mm APX antitank gun		MFS140	1936	1.7	855	3000	550	17	4450	38	6	15
	5-cm Pak 38 (L/60) antitank gun		MFS143	1940	2.25	1130	3000	1500	13	4170	38	5	15
	6-pdr antitank towed gun		MFS082	1940	1.42	1219	3000	1500	15	4640	92	6	15
	7.5-cm Pak 40 antitank gun		MFS076, MFS144	1941	4.05	990	3000	1800	14	9625	100	6	20
	17-pdr antitank towed gun		MFS081	1942	3.4	1200	3000	1500	20	13120	147	6	20
	17-pdr antitank towed gun, v.2		MFS081	1942	7.7	950	3000	1500	10	13120	147	5	20
	8.8-cm Pak 43		MFS103	1943	10.4	1000	3000	2000	6	16850	133	6	20
	2A17 "D-30" in antitank role		MFS157	1960	10.25	1575	3000	870	8	13700	200	6	20

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Towed guns	100mm antitank gun T-12		MFS110, MFS157	1961	4.55	1548	3000	1850	7	15650	240	6	25
	2A36 "Giatzint-B" in antitank role		MFS157	1975	19.8	1575	3000	1530	6	26000	330	8	20
	2A65 "Msta-B"		MFS157	1986	19.8	1575	3000	2130	6	16100	240	6	20
	2A45M Sprut-B smoothbore 125mm antitank towed gun		MFS111	1989	4.85	1715	3000	2000	7	19600	240	7	25
Machine guns	Gatling gun 1870, 1.0 caliber		MFS168e	1866	0.2551	400	2000	1100	360	5014	6.8	8	5
	Gatling gun 1870, 0.50 caliber		MFS168d	1871	0.0319	400	2000	1100	720	2605	3.5	5	5
	Gatling gun 1870, 0.45 caliber		MFS168c	1874	0.02325	400	2000	1100	800	1687	2.4	4	5
	Hotchkiss Mle 1897		MFS195a	1897	0.0128	720	160	800	600	682.5	0.7	7	3

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Machine guns	pre-1900 Maxim 45 caliber on artillery-like carriage		MFS169a	1889	0.031	412	2000	1100	400	1338	1.7	7	5
	Skoda 1893		MFS197	1893	0.016	541.5	160	800	350	682.5	0.7	7	3
	Hotchkiss .303 Mk I		MFS195	1901	0.011	739	160	800	500	487.5	0.5	5	4
	Madsen 1904		MFS193	1904	0.0128	738	160	720	450	390	0.4	4	4
	Schwarzlose 1907		MFS196	1907	0.015	615	160	800	400	682.5	0.7	7	3
	German Maxim MG08, crew 9		MFS159a	1908	0.0117	860	2000	800	450	849	0.9	9	3
	German Maxim MG08, crew 4		MFS159b	1908	0.0117	860	2000	800	450	394	0.4	4	3
	Hotchkiss Portative Mle1909		MFS173	1909	0.0128	665	160	500	500	292.5	0.3	3	4
	Russian PM1910		MFS170	1910	0.0097	863	2000	800	550	749	0.8	8	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Machine guns	Vickers Mk1, crew 3		MFS171	1912	0.0112	745	160	800	450	293	0.3	3	3
	Vickers Mk1, crew 6		MFS171a	1912	0.0112	745	160	800	450	586	0.6	6	3
	Lewis Mk1		MFS172	1915	0.0096	863	160	800	500	195	0.2	2	4
	German Maxim MG08/15, crew 4		MFS159, MFS158, MFS204	1916	0.0117	860	2000	400	450	394	0.4	4	4
	Browning M1917 crew 6		MFS174	1917	0.0096	853	160	800	600	585	0.6	6	3
	Vickers-Berthier		MFS177	1917	0.0113	745	160	550	600	292.5	0.3	3	3
	Browning Automatic Rifle M1918A2		MFS175	1918	0.00995	850	160	600	650	195	0.2	2	4
	Chatellerault Mle 24/29		MFS176	1924	0.00898	823	160	500	500	292.5	0.3	3	3
	Bren Mark 1		MFS178	1926	0.0113	731	160	800	500	292.5	0.3	3	4
	Fiat 12mm		MFS215	1926	0.04	940	160	1850	600	585	0.6	6	2

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Machine guns	Vickers 12.7mm		MFS214	1927	0.037	778	160	1850	600	585	0.6	6	2
	Hotchkiss 13.2mm or Breda 31		MFS213	1929	0.052	800	160	1850	450	585	0.6	6	2
	M2HB of 1930s		MFS202	1933	0.042	915	160	1850	550	585	0.6	6	2
	German MG34 w/ tripod		MFS179, MFS205	1933	0.0128	755	160	1850	900	585	0.6	6	3
	German MG34 w/ bipod		MFS179a, MFS205	1933	0.0128	755	160	800	900	292.5	0.3	3	3
	DShK38		MFS181	1938	0.0512	855	2000	2000	575	487.5	0.5	5	2
	German MG42 w/ tripod		MFS180, MFS205	1942	0.0128	755	160	1850	1150	585	0.6	6	3
	German MG42 w/ bipod		MFS180a, MFS205	1942	0.0128	755	160	800	1150	292.5	0.3	3	3
	Browning M1917 crew 3		MFS174a	1943	0.00958	853	160	800	600	292.5	0.3	3	3

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Machine guns	Goryunov SG43		MFS182	1943	0.01196	863	2000	1000	650	487.5	0.5	5	3
	Degtiarev RPD M1927		MFS190	1944	0.0079	718	160	800	600	195	0.2	2	4
	FN MAG		MFS183	1954	0.00943	853	160	1200	850	292.5	0.3	3	3
	MG3 - bipod		MFS201	1958	0.01	850	160	600	1300	195	0.2	2	4
	MG3 - tripod		MFS201	1958	0.01	850	160	1200	1300	390	0.2	4	3
	US M60		MFS185	1960	0.00898	865	160	1800	550	292.5	0.3	3	3
	HK21		MFS184	1961	0.0097	800	160	1200	750	195	0.2	2	3
	Soviet PK		MFS186	1963	0.01195	825	160	1000	700	195	0.2	2	4
	M2HB of 1970s		MFS202a	1970	0.042	915	160	1850	550	292.5	0.3	3	2
	Soviet NSV-12.7		MFS191	1974	0.0483	860	160	2000	800	195	0.2	2	2
	STK 50MG		MFS212	1989	0.042	890	160	1850	600	195	0.2	2	2
	M240G of 1990s		MFS203	1996	0.01	840	160	1800	950	292.5	0.3	3	3
	Kord		MFS192	1998	0.0483	860	160	2000	750	195	0.2	2	2
	PKP Pecheneg		MFS200	2001	0.0097	900	160	1500	800	195	0.2	2	4

Table 1 Data set of ground-mobile, direct-fire weapon systems (continued)

System type	System	Notes in Section 4 of ARL-SR-0417	Notes in Section 5 of ARL-SR-0417, or in Section 3.2 of this report	Year of introduction (CE)	Projectile mass (kg)	Muzzle velocity (m/s)	Protection (J)	Effective range (m)	Rate of fire (rounds per min)	System mass (kg)	System motive power (hp)	Crew	Offroad speed (kph)
Technicals	Ford T with Lewis MG		MFS209a	1916	0.0096	863	160	600	550	996	20	3	20
	Tachanka w/ PM1910		MFS206	1920	0.0097	863	160	800	550	2975	4	3	15
	Chevrolet C-20 with ZPU-4		MFS210c	1978	0.06	1005	160	1500	1200	2790	115	3	20
	Land Rover w/ DShK		MFS210a	1978	0.051	855	160	1000	675	2017	86	3	20
	Land Cruiser BJ45 w/ ZPU-2		MFS210b	1984	0.06	1005	160	1500	1200	2480	80	3	20
	Unimog 404 w/ ZPU-4		MFS210e	1993	0.06	1005	160	1500	2400	5000	110	3	20
	Unimog 404 w/ ZU-23-2		MFS210f	1993	0.18	970	160	1250	2000	5000	110	3	20
	Ford F-350 Super Duty w/ ZPU-4		MFS210d	2015	0.06	1005	3000	1500	2400	3900	300	3	20

3.2 Notes on Sources

This section contain notes numbered from Notes MFS152 through MFS221. Notes with lower numbers (prepended with MFS) are found in Section 5 of ARL-SR-0417 (Kott 2019a). Note the numbers are not necessarily consecutive; there are gaps in the number sequence.

MFS152: From Rogers (1975):

- p. 35: In 1550, Culverin – 15-pounder (pdr), weight 4000 lb, drawn by 17 horses; bastard culverin – 7-pdr, 2500 lb, 11 horses; culverin moyane – 2-pdr, 1200 lb, 4 horses; falcon – 1-pdr, 700 lb, 3 horses; and falconet – 3/4-pdr, 410 lb, 2 horses. There were limbers and trails were dragging on the ground, reducing the weight that a horse could pull.
- p. 43: In the 1640s, cannon of 7000 lb required 15 pairs of horses; a demi-cannon of 4500 lb and 900-lb carriage required 11 pairs of horses; and a small drake of 250 lb required 1 horse. At that time, some form of limber existed. Culverin: 15-pdr, 5-inch caliber, 1.75 tons, pulled by 8 horses, 460 yd point blank. Demi-culverin: 4.4-inch caliber, 9-pdr, 1.5 ton, 400 yd point blank range. Saker: 1 ton, 3.5-inch caliber, 5-pdr, 360 yd point blank range. Minion: 0.75 ton, 3-inch caliber, 4-pdr. Falcon: 0.25 ton, 2.75-inch caliber, 2-pdr, 320 yd point blank range. Falconet: 200 lb weight, 2-inch caliber, 1-pdr. Robinet: weight 100 lb, 1.25 caliber, 3/4-pdr.

[Data compiler's note: For the previous two paragraphs, I do not consider artillery pieces drawn by more than eight horses; these do not appear to me as "field-mobile" artillery. When the number of horses is not given, I assume one horse for 500 lb of the weight (probably metal only) given (see the p. 46 note that follows). For calculating the total system mass, I assume that a horse was 500 kg and pulled 250 kg of weight. Crew is assumed based on other contemporary (actually, mostly later) pieces. For muzzle velocity and rate of fire, see Note MFS216.]

- p. 46: Horses were calculated on the basis of one horse per 500 lb of metal, but others recommended 350 lb per horse.
- p. 55–56: Light cavalry of Frederick the Great, mid 1700s: 6-pdr gun drawn by six strong horses driven by three drivers; eight gunners, on horses; limber carried 100 rounds. Starts fire when 600–700 paces from the enemy.
- p. 57: Also by Frederick the Great: opens fire against cavalry at 800–900 paces.

- p. 65: In 1747, British artillery: 12-pdr gun required 15 horses; 9-pdr – 11; 6-pdr – 7; and 3-pdr – 4. Spare limber for 12- or 9-pdr – 2 horses; 6- or 3-pdr – 1 horse.
- p. 190: "There has been comparatively little development in ordnance and its mounting since the introduction the long-recoil carriage."

MFS153: From Foss (2002):

Offers broad coverage of tanks, light armored vehicles, armored cars, and self-propelled guns from the early 1900s to early 2000s. For most vehicles, provides the name and caliber of the armament, range of armor thickness, weight, power of the power plant, and road speed. These were used to compare and confirm other sources.

MFS155: From Citino (1994):

Offers a list of tanks he considers significant. For each, provides weight, maximum thickness of armor, speed (apparently on a road), caliber of the armament, and crew.

MFS156: From Dastrup (1994):

- Appendix 3, English ordnance, 1640s: Saker 2500 lb, shot 5.25 lb; Minion 1500 lb, shot 4 lb; Falcon 700 lb, shot 2.25 lb; Falconet 210 lb, shot 1.25 lb; and Robinet 120 lb, shot 0.75 lb.
- Appendix 4, French ordnance, 1666: Saker weight (probably metal only) 1700 lb, projectile 6 lb; 16th-century cannon weight 1100 lb, projectile 3 lb; and 32nd cannon weight 750 lb, projectile 1.5 lb.

[Data compiler's note: For entering the data based on the previous, I use the same approach as discussed in MFS152.]

MFS157: From Grau and Bartles (2018):

- p. 210: Modern (2017?) motorized rifle squad on BTRs includes machine gunner and assistant machine gunner, implying a crew of two per HMG, such as a PKM (p. 217: 7.52 × 54mm round; 600 rpm, max effective range [effrange] 1500 m).
- p. 211: However, a similar squad on BM/s includes only one machine gunner, implying a single operator of a light machine gun (LMG), such as an RPK (p. 215: 7.62 × 39mm round; effective to 1000 m, weight 10 lb) or

PKP Pecheneg (p. 215: 7.62 × 39mm round; effrange 1500 m; weight 18 lb).

- p. 226: Tank guns:
    - L/55 Rheinmetall 120mm, muzzle energy 12.7 MJ *[Data compiler's note: Unknown whether this includes the sabot.]*; muzzle velocity 1700 m/s; effrange 4000 m; rate of fire 6–8 rpm
    - Russian 2A82-1M, 125mm, muzzle energy 15.24 MJ *[Data compiler's note: Unknown whether this includes the sabot.]*; muzzle velocity is unspecified; effrange 4700 m; rate 12 rpm.
    - Russian 2A83, 152mm, muzzle energy less than 20 MJ *[Data compiler's note: Unknown whether this includes the sabot.]*; muzzle velocity 1980 m/s; effrange 5100 m; rate 15 rpm.
- p. 227: Comparison of T-71, T-72B3, and T-90 tanks.
- p. 229–230: New type of MFS, Russian BMPT such as Terminator-2; protected as a tank and can maneuver together with tanks, but with weapons more suitable for defeating non-tank targets, especially mounted and dismounted antitank infantry. Based on the T-72, 47 tons, crew 5, dual 2A42 30mm autocannon, effective against lightly armored targets at 2500 m, unarmored at 4000 m.

  [Data compiler's note: Also see Wikipedia (2019c) and Arcus (n.d.).]
- p. 233: Russian towed artillery, all can be used in direct-fire anti-armor mode, with anti-armor rounds, as follows:
    - 2A19 "MT-12 Rapira", 100mm, range 1850 m, system mass 2750 kg, 7 rpm, towed by KRAZ, crew 6.
    - *[Data compiler's note: Also see Note MFS110.]*
- 2A18 "D-30", 122mm, direct-fire range 870 m, system mass 3200 kg, 8 rpm, crew 6, tow vehicle Ural. *[Data compiler's note: Assume with vehicle weight 9000 kg and 200-hp engine (Wikipedia 2019n).]*

[Data compiler's note: As antitank rounds data for this system are not readily available, I approximate roughly by scaling up the data on a 3BM-2 round, APFSDS-T tungsten, with projectile weight 5.65 kg and muzzle velocity 1,575 m/s. See Wikipedia (2019b).]

- 2A65 "Msta-B", 152mm, range 2130 m, system mass 3100 kg, 6 rpm, crew 6, towed by MT-LB. *[Data compiler's note: MT-LB APC; weight*

11900 kg; assume 1000 kg crew and ammo. Ballistics is estimated as explained previously.]

- 2A36 "Giatzint-B", 152mm, range 1530 m, system mass 9500 kg, 6 rpm, KRAZ, crew 8. *[Data compiler's note: Assume as per Wikipedia (2019h), 330 hp, estimated vehicle weight 15000 kg; assume 1000 kg crew and ammo. Ballistics is estimated as explained previously.]*

MSF158:

From Cron (2002):

- p. 121: In 1914, a machine gun company consisted of 97 officers and other ranks, with 6 machine guns, each drawn by 4 horses.
- p. 122: Introduction of LMG 08/15 was necessary because the HMG 08 could not be relocated quickly enough.
- p. 123: In 1916, the number of machine guns per machine gun company was increased to 12.

  [Data compiler's note: This could be interpreted as consistent with reduction of the machine gun crew from seven to three.]

From Walter (2005):

- German MG. 08, weight 26.5 kg, 860 m/s, 300 rpm. Here the MG 08 team is claimed to be four (see Ferguson [2019b]).

MSF159: From German Army Handbook (1918):

- p. 54: In 1916, a machine gun marksman section included 6 gun commanders, 20 lance-corporals, and 40 machine gunners in addition to other support personnel and 6 "spare men". *[Data compiler's note: Apparently for six machine guns in the unit.]*
- p. 56: Later (1917?), a machine gun company included 12 gun commanders and 105 privates and lance corporals, plus support personnel. *[Data compiler's note: Apparently for 12 machine guns.]*
- p. 58: The 08 machine gun had the following: muzzle velocity 2821 fps; rate of fire 400–500 rpm.
- p. 59: Training of expert machine gunners was limited to firing at 800 m.

- p. 61: A 08/15 LMG group consisted on one non-commissioned officer (NCO) and eight men with one machine gun. *[Data compiler's note: Wikipedia says the crew was four.]*
- p. 168: A photograph of a machine gun unit represents one NCO and six men with 08 machine gun.

From Hogg (2002):

- German Maxim MG 08, 7.92 × 57, 1908, 2838 fps, 450 rpm.

From Walter (2005):

- p. 11: A photo of a Belgian crew of a Maxim gun on tripod, circa 1910; four men.

MSF159a:

- System: German Maxim MG08, crew of 9
- Sources:
  - Note MFS158
  - Note MFS159
- Year: 1908
- Projectile Mass (Projmass): based on 7.92 × 57 Mauser, 11.7 g
- Velocity: 2821 fps, 860 m/s
- Effrange: 800 m
- Rate: 450 rpm
- Protection: 2000 (shield)
- HP: 0.9
- Crew: 9
- System Mass (Sysmass): see Note MFS170b
- Offroad speed: considering the comments about the need for higher mobility, assume 3 kph, somewhat slower than the assumption for light infantry

MSF159b:

- System: German Maxim MG08, crew of 4
- Sources:
  - Note MFS158
  - Note MFS159
- Year: 1908
- Projmass: based on 7.92 × 57 Mauser, 11.7 g
- Velocity: 2821 fps, 860 m/s
- Effrange: 800 m
- Rate: 450 rpm
- Protection: 2000 (shield)
- HP: 0.4
- Crew: 4
- Sysmass: see Note MFS170b
- Offroad speed: considering the comments about the need for higher mobility, assume 3 kph, somewhat slower than the assumption for light infantry

MSF160:

I reconsidered and decided to delete the entries for harquebusier and cuirassier. I do not have a satisfactory approach to quantifying edge weapons. Thus, Notes MFS048 and MFS049 are no longer applicable to this data set.

MFS161:

- System: British QF 18-pdr
- Sources:
  - Wikipedia (2019k)
  - Note MFS144
- Year: 1904
- Projmass: 8.4 kg

- Velocity: 492 m/s
- Effrange: 6,000 m (indirect); for direct fire, I make the same assumption as for French 75mm – 1800 m.
- Rate: 20 rpm
- Protection: gun shield – 3000 J
- HP: 6 horses and 6 men – 6.6
- Crew: 6
- Sysmass: inconsistent data, but probably 2000 kg
- Offroad speed: the gun was originally intended as horse artillery, but appears too heavy. Assume 5 kph.

MFS162:

- System: German gun of 96 m/A pattern: caliber 77mm
- Sources:
    - Wikipedia (2019a)
    - Note MFS159

From German Army Handbook, 1918 (1977):

- p. 69: A battery of 4 guns (77mm), each 6-horsed, included 6 officers and 130 other ranks.
    - Year: 1896
    - Velocity: muzzle velocity with normal charge and 1915 shell, 1571 fps; with super-charge and stream-line shell (C-Geschloss), 1968 fps
    - Sysmass: weight of gun in action, 27.5 cwt; weight of gun limbered up without gunners, 35.6 cwt
- p. 71–72:
    - Gun of 96-m/A pattern: caliber 77mm, weight of gun in action, 19.3 cwt; weight of gun limbered up without gunners, 45 cwt; muzzle velocity with normal charge and 1915 shell, 1526 fps.
    - Gun of 1916 pattern: caliber 77mm, weight of gun in action, 27.5 cwt; weight of gun limbered up without gunners, 35.6 cwt;

muzzle velocity with normal charge and 1915 shell, 1571 fps; with super-charge and stream-line shell (C-Geschloss), 1968 fps.

MFS168:

- System: 0.45-inch caliber Gatling gun, c.1870s

From US Artillery School (1978):

- All three calibers (1, 0.5, and 0.45 inch) have 10 barrels, are on carriages, and pulled by some number of horses (for 0.45-inch caliber, the document mentions "animal" in singular).
- Total weights are (for these calibers), including gun, gun carriage, two wheels, limber and two wheels, ammunition chest, and other components: 3,263, 1,699.5, and 925 lb.
- Projectile weight: The 1-inch solid-ball cartridge is made up as follows:
    - Projectile 3,942 gr *[Data compiler's note: 0.2551 kg.]*
    - Metallic case: 1,382
    - Powder: 500
    - Lubricant: 51
    - Total: 5,875 gr

  [Data compiler's note: For other calibers, assume proportional weights for projectile; for 0.50-inch caliber, 0.0319 kg; for 0.45-inch caliber, 0.02325 kg.]
- Teams: 8, 5, and 4 men (for 1.0-, 0.5-, and 0.45-inch calibers, respectively).

From GPO (1978):

- Guns purchased were as follows (partial list): fifty 6-barrel, caliber 1-inch, model 1866; fifty 6-barrel, caliber 0.50-inch model 1866; nine 10-barrel caliber 0.50-inch model 1871; multiple (total about 159) 10-barrel guns, long and short, caliber 0.45-inch, models 1874, 1875, 1876, and 1877.

MFS168a: From Ellis (1986):

- Gatling gun, 1874, caliber of 0.45 inch, 800 rpm.

MFS168b: From Hogg (2002):

- p. 20–22: Describing a test performed in 1870 on a Gatling gun model produced probably in the 1865 period: caliber 0.45 inch, 1925 rounds fired in 2.5 min *[Data compiler's note: Consistent with Note MFS168a.]*, weight 2016 lb *[Data compiler's note: Whether this includes the carriage is unknown]*, pulled by two horses *[Data compiler's note: Two horses are unlikely to pull 2016 lb.]*, and effrange about 1200 yd.

MFS168c:

- Gatling gun 1874, 0.45-inch caliber
- Sources:
    - Note MFS168
    - Note MFS168a
    - Note MFS168b
- Year: 1870
- Projmass: 0.02325 kg
- Velocity: data for rifles of 1861–1873 tend to show muzzle velocity ranging 390–440 m/s. I assume 400 m/s in absence of specific data about the Gatling gun's muzzle velocity.
- Effrange: 1200 yd, 1100 m
- Rate: 800 rpm
- Protection: the gun carriage included a shield; I assume optimistically that it protected from a contemporary rifle with muzzle velocity of about 2000 J.
- HP: 2.4; I assume 2 horses because based on Notes MFS036 and MFS053; a horse could pull about 500–600 lb.
- Crew: 4
- Sysmass: 2 horses are 1000 kg, plus gun with carriage and ammunition was 925 lb = 419 kg and plus a crew of 4; total 1687 kg
- Offroad speed: assume same as foot artillery, 5 kph

MFS168d:

- Gatling gun 1871, 0.5-inch caliber
- Sources:
    - Note MFS168
    - Note MFS168a
    - Note MFS168b
- Year: 1870
- Projmass: 0.0319 kg
- Velocity: data for rifles of 1861–1873 tend to show muzzle velocity ranging 390–440 m/s. I assume 400 m/s in absence of specific data about the Gatling gun's muzzle velocity.
- Effrange: 1200 yd, 1100 m
- Rate: 720 rpm *[Data compiler's note: Based on dimensional scaling relations, the rate should be inversely proportional to caliber.]*
- Protection: the gun carriage included a shield; I assume optimistically that it protected from a contemporary rifle with muzzle velocity of about 2000 J.
- HP: 3.5; I assume 3 horses because based on Notes MFS036 and MFS053; a horse could pull about 500–600 lb.
- Crew: 5
- Sysmass: 3 horses are 1500 kg, plus gun with carriage and ammunition was 1700 lb = 770 kg and plus a crew of 5; total 2605 kg
- Offroad speed: assume same as foot artillery, 5 kph

MFS168e:

- Gatling gun 1866, 1.0-inch caliber
- Sources:
    - Note MFS168
    - Note MFS168a
    - Note MFS168b

- Year: 1870
- Projmass: 0.2551 kg
- Velocity: data for rifles of 1861–1873 tend to show muzzle velocity ranging 390–440 m/s. I assume 400 m/s in absence of specific data about the Gatling gun's muzzle velocity.
- Effrange: 1100 m
- Rate: 360 rpm *[Data compiler's note: Based on dimensional scaling relations, the rate should be inversely proportional to caliber.]*
- Protection: the gun carriage included a shield; I assume optimistically that it protected from a contemporary rifle with muzzle velocity of about 2000 J.
- HP: 6.8; I assume 6 horses because based on Notes MFS036 and MFS053; a horse could pull about 500–600 lb.
- Crew: 8
- Sysmass: 6 horses are 3000 kg, plus gun with carriage and ammunition was 3263 lb = 1478 kg and plus a crew of 8; total 5014 kg
- Offroad speed: assume same as foot artillery, 5 kph

MSF169:

From Chamber (1897):

- On early Maxim guns, contains diagrams and weights, and shows artillery-like field carriage.
- Caliber: 0.45 inch; bullet 480 gr.
- Long belt contained 334 rounds and weighted filled 43.75 lb. Box with one belt was 54 lb.
- Weight of gun: 60 lb. Mounting (?) without shield – 100 lb, shield alone 65 lb. Tripod is mentioned as a mounting option, but no weight is given. Seven boxes of ammunition per field carriage; no limber is provided.
- Wheels: 4 ft in diameter
- Number of horses or crew: not given

From Hogg (2002):

- Maxim UK Mk1, caliber 0.45 inch, 1889, 60 lb, 1350 fps, 400 rpm.
- p. 8: Photo shows Maxim gun on artillery-like carriage, in 1896.

From Walter (2005):

- p. 29: A photo of British Maxim gun on an artillery-like carriage, in 1902.

From Ellis (1986):

- p. 64: Even in the Boer War Maxims were mounted on a carriage that weighted four hundredweight with wheels. *[Data compiler's note: Assuming British cwt of 50.8 kg, this is about 200 kg.]*

MFS169a:

- System: pre-1900 Maxim 0.45-inch caliber on artillery-like carriage
- Source: Note MSF169
- Year: 1889
- Projmass: 480 gr, 0.031 kg
- Velocity: 1350 fps, 412 m/s
- Effrange: assume 1100 m, similar to the 0.45-inch Gatling gun
- Rate: 400 rpm
- Protection: 2000 J (assumed to account for the shield)
- HP: 1.7
- Crew: 7
- Sysmass: I assume one horse, pulling a carriage with ready ammunition and implements with a total weight 250 kg and a crew of seven (compare later with the Maxim and Vickers data), each of whom was 60 kg and bearing a typical load of 40% of their weight (24 kg). See Note MFS015. Total: 500+250+7×84 = 1338 kg.
- Offroad speed: assume same as foot artillery, 5 kph

MFS170:

- Russian PM1910 (Maxim)

- Sources:
    - From UK General Staff (1996):
        - p. 40: Each gun has a detachment of 1 NCO, 7 men, and 2 drivers.
        - p. 131: The description of tactics for machine guns implies that in attack, they must advance at the pace of the attacking infantry.
    - From Hogg (2002):
        - Russian Maxim M1910, 7.62 × 54, 1910, 2830 fps, 550 rpm.
    - From Walter (2005):
        - Sokolov mount weight was 45.2 kg.
        - p. 113: Russian Standard M1905, chambering 7.62 × 54 (M1891 ammunition), weight 28.3 kg w/ coolant, 640 m/s, 300 rpm
- Year: 1910
- Projmass: 9.7 g
- Velocity: 863 m/s
- Effrange: 800 m; see Note MFS159
- Rate: 550 rpm
- Protection: 2000 J (assumed to account for the shield)
- HP: 0.8
- Crew: 8
- Sysmass: see Note MFS170b
- Offroad speed: assume same as for light infantry, 4 kph

MFS170a:

In case of crew-served machine guns, the number of personnel in the crew (the crew number) plays especially important role. It is shown in Kott (2019b) that the Figure of Regularity (FoR) is roughly inversely proportional to the crew number. In addition, FoR is inversely dependent on the mass of the overall system, and in the

case of machine guns, the mass is dominated by the crew. Thus, the FoR is disproportionately influenced by the crew number.

Unfortunately, throughout history, the crew number has been influenced by numerous factors and has fluctuated significantly, even in the case of essentially the same machine gun model. The crew number seems dependent on availability of personnel (e.g., by the end of a major war the crew number tended to be reduced). It also depended on the culture of the military force, its doctrine, and the organizational structure within which the crew was placed. The crew number also tends to decline with historic time. It is also likely that the actual crew number in combat was often smaller than the officially allowed number.

With all these complexities in mind, I tried to use documented numbers whenever possible. When I did not have any specific information, I made the following assumptions. I differentiated between the LMGs and HMGs. The LMG category, for my purposes, includes a machine gun that is normally fired with a bipod; typically weighs under 12 kg; and when necessary, can be fired by a soldier while standing or walking. The HMG category here includes a machine gun that is normally fired from a tripod or a field mount such as the Sokolov mount; typically the weight with a tripod was well over 20 kg; and cannot be reasonably fired by a soldier while holding it in their hands. I include all machine guns of caliber less than 6mm in the LMG category, and all guns of caliber greater than 11mm in the HMG category. For LMG, I assume the following crew numbers: 1870–1916, 3; 1917–1942, 3; and 1943–2019, 2. For HMG, I assume the following crew numbers: 1870–1916, 7; 1917–1942, 5; and 1943–2019, 4. These numbers are broadly consistent with most of the published numbers I was able to locate (e.g., Notes MFS171, MFS171a, MFS172, MFS175, MFS179, MFS185, MFS187, MFS188, MFS189, MFS190, MFS191, MFS193, MFS198, MFS199, MFS202, MFS203, MFS204, and MFS205).

MFS170b:

I assume that the weight of the gun, mounts (if any), ammunition, water (if any), and other supplies and implements are divided among the crew in such a way that each person (65 kg each) carries 50% of their weight (32.5 kg each); see Note MFS015. Thus, the total mass of the system is the number of crew times 97.5 kg.

MFS170c:

Generally, I made the following assumptions regarding the characteristic speed of the mobile system consisting of a crew with a machine gun. For LMG and HMG cases, where the literature explicitly states that the machine gun was to keep pace

with infantry, I assumed the same speed as assumed for light infantry, 4 kph, and for HMG, a reduction in speed to 3 kph. For HMG with a caliber over 11mm, I assumed a further reduction to 2 kph.

MFS171:

- System: Vickers Mark 1, assumed crew 3
- Sources:
    - From Hogg (2002):
        - Vickers Mark 1, year 1912, .303 British, 18.1 kg, 745 m/s, 3121 J, 450 rpm. *[Data compiler's note: A Vickers gun team of six or three?]*
    - From Coppard (1999):
        - George Coppard explained how the Vickers gun team worked: "Number One was leader and fired the gun, while Number Two controlled the entry of ammo belts into the feed-block. Number Three maintained a supply of ammo to Number Two, and Number Four to Six were reserves and carriers, but all the members of the team were fully trained in handling the gun."
- Year: 1912
- Projmass: 0.0112 kg
- Velocity: 745 m/s
- Effrange: 800 m (based on Note MFS159)
- Rate: 450 rpm
- Protection: 160
- HP: 0.3
- Crew: 3
- Sysmass: see MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS171a:

- System: Vickers Mark 1, crew 6

- Source: Ferguson (2019c)
- Year: 1912
- Projmass: 0.0112 kg
- Velocity: 745 m/s
- Effrange: 800 m (based on Note MFS159)
- Rate: 450 rpm
- Protection: 160
- HP: 0.6
- Crew: 6
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS172:

- System: Lewis MG, Mk1
- Sources:
    - Hogg and Weeks (2000)
    - Hogg (2002)
        - Lewis US M1917, 0.30 M1906, 11.45 kg, 863 m/s, 3568 J, 500 rpm, 600 m.
        - UK Lewis Mk 1, 1914, 25 lb, 2450 fps, 550 rpm.
- Year: 1915
- Projmass: 3568 J
- Velocity: 863 fps
- Effrange: 800 m
- Rate: 500 rpm
- Protection: 160
- HP: 0.2
- Crew: 2 (Ferguson 2019a), but SADJ (2013) says the crew was 5.

- Sysmass: see Note MFS170b
- Offroad speed: 4 kph; see Note MFS170c

MFS173:

- System: Hotchkiss Portative Mle 1909
- Source: Hogg (2002): 8×50R Lebel
- Year: 1909
- Projmass: calculate from KE and muzzle velocity
- KE: 2825 J
- Velocity: 665 m/s
- Effrange: 500 m (assume 500 m for LMGs, 800 m for HMGs)
- Rate: 500 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3 (see Note MFS170a)
- Sysmass: see Note MFS170b
- Offroad speed: 4 kph; see Note MFS170c

MFS174:

- System: Browning M1917, crew 6
- Sources:
    - Hogg (2002):
        - Browning M1917: cartridge 30-06, 14.97 kg, 853 m/s, 3485 J, 600 rpm
    - Walter (2005):
        - 500 rpm
- Year: 1917
- Projmass: calculate from KE and muzzle velocity
- KE: 3485 J

- Velocity: 853 m/s
- Effrange: 800 m (assume 500 m for LMGs, 800 m for HMGs)
- Rate: 600 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 6; see Note MFS199
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS174a:

- System: Browning M1917, crew 3
    - Sources: Hogg (2002):
        - Browning M1917: cartridge 30-06, 14.97 kg, 853 m/s, 3485 J, 600 rpm
    - Walter (2005):
        - 500 rpm
- Year: 1943 (same as Note MFS174, but with reduced crew)
- Projmass: calculate from KE and muzzle velocity
- KE: 3485 J
- Velocity: 853 m/s
- Effrange: 800 m (assume 500 m for LMGs, 800 m for HMGs)
- Rate: 600 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3; see Note MFS199
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS175:

- System: Browning Automatic Rifle M1918A2
- Source: Hogg (2002): cartridge 0.30 M1906, 8.8 kg
- Year: 1918
- Projmass: calculate from KE and muzzle velocity
- KE: 3594 J
- Velocity: 850 m/s
- Effrange: 600 m
- Rate: 650 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 2 (see Royal Armouries [2019])
- Sysmass: see Note MFS170b
- Offroad speed: 4 kph; see MFS170c

MFS176:

- System: Chatellerault Mle 24/29
- Sources:
    - Hogg (2002):
        - Chatellerault Mle 24/29, 1924, 9.18 kg, 823 m/s, 3042 J, 500 rpm
    - Walter (2005):
        - Chatellerault M1924/29, chambering 7.5 × 54, weight 8.93 kg, 870 m/s, 450 rpm
- Year: 1924
- Projmass: calculate from KE and muzzle velocity
- KE: 3042 J
- Velocity: 823 m/s

- Effrange: 500 m (assume 500 m for LMGs, 800 m for HMGs)
- Rate: 500 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3; Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS177:

- System: Vickers-Berthier
- Source: Hogg (2002)
- Year: 1917
- Projmass: calculate from KE and muzzle velocity
- KE: 3121 J
- Velocity: 745 m/s
- Effrange: 550 m
- Rate: 600 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3; Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS178:

- System: Bren Mark 1
- Source: Hogg (2002)
- Year: 1926
- Projmass: calculate from KE and muzzle velocity

- KE: 3024 J
- Velocity: 731 m/s
- Effrange: 800 m (assume 500 m for LMGs, 800 m for HMGs)
- Rate: 500 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3; Note MFS170a; also see Note MFS189
- Sysmass: see Note MFS170b
- Offroad speed: 4 kph; see Note MFS170c

MFS179:

- System: German MG34 as HMG
- Sources:
    - Hogg (2002):
        - MG34, 1933, 12.0 kg, 755 m/s, 3654 J, 900 rpm, 550 m w/ bipod, 1850 m w/ tripod
    - TTT (1944):
        - WW2 German LMG team was three men, HMG same as LMG but on tripod, LMG is on bipod; MG34 was 900 rpm and MG42 was 1150 rpm. HMG effrange was 1500–2000 yd, LMG effrange was 800 yd.
- Year: 1933
- Projmass: calculate from KE and muzzle velocity
- KE: 3654 J
- Velocity: 755 m/s
- Effrange: 1850 m (assume tripod)
- Rate: 900 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew

- Crew: 5; see Notes MFS187, MFS188, and MFS205
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS179a:

- System: German MG34 as LMG
- Sources:
    - Hogg (2002):
        - MG34, 1933, 12.0 kg, 755 m/s, 3654 J, 900 rpm, 550 m with bipod, 1850 m with tripod
    - TTT (1944):
        - WW2 German LMG team was three men, HMG same as LMG but on tripod, LMG is on bipod; MG34 was 900 rpm and MG42 was 1150 rpm. HMG effrange was 1500–2000 yd, LMG effrange was 800 yd.
- Year: 1933
- Projmass: calculate from KE and muzzle velocity
- KE: 3654 J
- Velocity: 755 m/s
- Effrange: 800 m (assume bipod)
- Rate: 900 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3; see Notes MFS187, MFS188, and MFS205
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS180:

- System: German MG42

Sources:

- Hogg (2002):
  - MG42, 1942, 10.77 kg, 755 m/s, 3654 J, 1150 rpm, 550 m with bipod, 1850 m with tripod.
- TTT (1944):
  - WW2 German LMG team was three men, HMG same as LMG but on tripod, LMG is on bipod; MG34 was 900 rpm and MG42 was 1150 rpm. HMG effrange was 1500–2000 yd, LMG effrange was 800 yd.

- Year: 1942
- Projmass: calculate from KE and muzzle velocity
- KE: 3654 J
- Velocity: 755 m/s
- Effrange: 1850 m, assume tripod
- Rate: 1150 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 5; see Notes MFS187, MFS188, MFS205
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS180a:

- System: German MG42
- Sources:
  - Hogg (2002):
    - MG42, 1942, 10.77 kg, 755 m/s, 3654 J, 1150 rpm, 550 m with bipod, 1850 m with tripod.
  - TTT (1944):
    - WW2 German LMG team was three men, HMG same as LMG but on tripod, LMG is on bipod; MG34 was 900 rpm

and MG42 was 1150 rpm. HMG effrange was 1500–2000 yd, LMG effrange was 800 yd.

- Year: 1942
- Projmass: calculate from KE and muzzle velocity
- KE: 3654 J
- Velocity: 755 m/s
- Effrange: 800 m, assume bipod
- Rate: 1150 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3; see Notes MFS187, MFS188, and MFS205
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS181:

- System: DShK38
- Sources:
  - Hogg (2002):
    - DShK 38, 33.3 kg, 855 m/s, 18700 J, 575 rpm, 2000 m on wheeled tripod.
  - Walter (2005):
    - p. 137: Introduced in 1939, weight 33.3 kg, mount tripod 142 kg, 843 m/s, 580 rpm.
  - TRADOC (n.d.):
    - Weight with mount is 158 kg.
- Year: 1938
- Projmass: calculate from KE and muzzle velocity
- KE: 18700 J
- Velocity: 855 m/s

- Effrange: 2000 m
- Rate: 575 rpm
- Protection: 2000 (with shield)
- HP: 0.1 hp times the number of crew
- Crew: 5, Note MFS170a; (some websites indicate 4). *[Data compiler's note: Even with 5 crew, it is unclear how the system can be mobile; 158 kg weight means every member must carry over 30 kg of machinery, on average, without accounting for ammunition.]*
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS182:

- System: Goryunov SG43
- Sources:
    - Hogg (2002):
        - Goryunov SG43, 1943, 17.8 kg, 863 m/s, 4452 J, 650 rpm, 1000 m
    - Walter (2005):
        - Weight 13.8 kg, mount: wheeled tripod (Sokolov-like) 26.9 kg, 855 m/s, 600 rpm
- Year: 1943
- Projmass: calculate from KE and muzzle velocity
- KE: 4452 J
- Velocity: 863 m/s
- Effrange: 1000 m
- Rate: 650 rpm
- Protection: 2000 (with shield)
- HP: 0.1 hp times the number of crew
- Crew: 5; see Note MFS207

- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS183:

- System: FN MAG
- Source: Hogg (2002)
- Year: 1954
- Projmass: calculate from KE and muzzle velocity
- KE: 3429 J
- Velocity: 853 m/s
- Effrange: 1200 m
- Rate: 850 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3; Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS184:

- System: HK21
- Sources: Hogg (2002)
- Year: 1961
- Projmass: calculate from KE and muzzle velocity
- KE: 3104 J
- Velocity: 800 m/s
- Effrange: 1200 m
- Rate: 750 rpm
- Protection: 160 (unarmored infantry, no shield)

- HP: 0.1 hp times the number of crew
- Crew: 2; see Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS185:

- System: US M60
- Sources:
    - Hogg (2002):
        - US M60, 1960, 10.5 kg, 865 m/s, 3360 J, 550 rpm, 850 yd bipod, 2000 yd tripod
    - US Army (1964):
        - Weight 10.4 kg; tripod 8.5 kg; range of 0.5 probability of hitting target with 6–9 round burst: point target – 600 m, area target with bipod 800 m, area target with tripod – 1100 m; cyclic 550 rpm; on-crew load of ammunition – 600–900 rounds
- Year: 1960
- Projmass: calculate from KE and muzzle velocity
- KE: 3360 J
- Velocity: 865 m/s
- Effrange: 1800 m (tripod)
- Rate: 550 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3 (according to US Army [1964])
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS186:

- System: Soviet PK
- Source: Hogg (2002)
- Year: 1963
- Projmass: calculate from KE and muzzle velocity
- KE: 4068 J
- Velocity: 825 m/s
- Effrange: 1000 m
- Rate: 700 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 2 (per Note MFS170a); also see Note MFS157
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS187:

From Ivanov (2010):

- p. 2: The crew of MG34 consisted of three persons.
- p. 31: The effective range of MG34 was 2000–2500 m.

MFS188:

From Monetchikov (2005):

- p. 2: First formed in 1915, crew of Madsen machine gun was four.
- p. 22: “Ruchnoy” (hand-carried) MG34 had a crew of three; during WW2.
- p. 23: “Stankoviy” (on tripod) MG34 had a crew of five: commander, gunner, two ammunition carriers, and one carried the tripod; during WW2.

MS189:

From South African General Staff (1943):

- Describes training with Bren Mark I machine gun. Pages 27 and 36 explain that the crew consists of two men, the gunner and the number 2 who is responsible mainly for carrying magazines. However, "the second in charge of section" was heavily involved with providing directions to the machine gun crew.

MFS190:

- System: Degtyarev M1927
- Sources:
    - From RKKA (n.d., clearly post-1943):
        - p. 281: The gun is operated by one gunner; however, an assistant is assigned to the gunner for carrying boxes with ammunition belts, but when the help is not needed, the assistant fires their own weapon.
    - From Walter (2005):
        - Degtyarev M1927, chambering 7.62 × 54mm, weight 7.77 kg, 848 m/s, 600 rpm
    - I used mainly TRADOC (n.d.; https://odin.tradoc.army.mil/WEG/List/Infantry Weapons&Small_Arms&Light_Machine_Gun).
- Year: 1927 or 1944? (If 7.62 × 39mm, then probably 1944)
- Projmass: 7.62 × 39mm
- Velocity: 718 m/s
- Effrange: 800 m
- Rate: 600 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 2; see Note MFS170a
- Sysmass: see Note MFS170b

- Offroad speed: like infantry 4 kph

MFS191:

- System: Machine gun NSV-12.7
- Sources:
    - From Ministerstvo Oborony SSSR (1978):
        - p. 140: The machine gun NSV-12.7 is operated by the gunner and the assistant gunner. The latter is required to fight with their own weapon when not engaged in assisting the gunner.
        - pp. 3–7: Effrange 1500 m; cyclic rate 800 rpm; mass of the gun 25 kg, box of 50 rounds 11.1 kg, tripod 16 kg.
    - Most data listed here are per TRADOC (n.d.).
- Year: 1974
- Projmass: 12.7 × 108mm
- Velocity: 860 fps (per TRADOC [n.d.])
- Effrange: 2000 m
- Rate: 800 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 2
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 2 kph

MFS192:

- System: Kord (6P50) 12.7mm HMG
- Source: Jane's (2017)
- Cartridge: 12.7 × 108mm
- Weight: gun only: 25 kg; barrel: 9.25 kg; 50-round belt: 7.7 kg
- Rate of fire, cyclic: 600–750 rpm

- Muzzle velocity: 820–860 m/s
- Effective range: 2,000 m
- Velocity: 840 m/s
- Effrange: 2000 m
- Rate: 759 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew

  Crew: 2; assume similar to NSV, see Note MFS19. This web article (http://oruzheika.mybb.ru/viewtopic.php?id=3) claims that Kord is served by crew of 3.
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 2 kph

MFS193:

- System: Madsen Machine Rifle
- Sources:
  - Danish Recoil Rifle Syndicate (c1920s):
    - Describes Madsen models perhaps prior to 1915, or 1915–1920, 0.303 British version, 16 lb, 600 rpm, range of 800 yd is claimed with high accuracy, crew of 4 is recommended (gunner and 3 ammunition bearers).
  - Hogg (2002):
    - Madsen, 1904, 7.92 × 57, 20 lb, 2460 fps, 450 rpm.
  - Walter (2005):
    - Madsen Model 1902, chamber 8 × 58, weight 7.5 kg with bipod, 610 m/s, 450 rpm.
  - Also see Note MFS188.
- Year: 1904
- Projmass: 12.8 g
- Velocity: 2460 fps

- Effrange: 720 m
- Rate: 450 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 4 based on the sources mentioned
- Sysmass: see Note MFS170b
- Offroad speed: light infantry, 4 kph

MFS195:

- System: Hotchkiss .303 Mk I
- Source: Walter (2005)
- Year: 1901
- Projmass: 0.011 kg
- Velocity: 739 m/s
- Effrange: 800 m (assumed)
- Rate: 500 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 5; see Note MFS170a; in this case, I elect to assume a middle number between LMG and HMG.
- Sysmass: see Note MFS170b
- Offroad speed: light infantry, 4 kph

MFS195a:

- System: Hotchkiss Mle 1897
- Source: Hogg (2002): 8 × 50R Lebel
- Year: 1897
- Projmass: 12.8 g
- Velocity: 2400 fps

- Effrange: 800 m
- Rate: 600 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 7; see Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS196:

- System: Schwarzlose 1907
- Sources:
    - Hogg (2002): Schwarzlose, 1907, 8 × 50R, 44 lb, 2050 fps, 400 rpm
    - Walter (2005): 575 m/s, 400 rpm
- Year: 1907
- Projmass: 15 g
- Velocity: 2050 fps
- Effrange: 800 m (assumed as contemporary Maxim)
- Rate: 400 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 7
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS197:

- System: Skoda 1893
- Sources:
    - Hogg (2002): Skoda, 1893, 8 × 52R, 1805 fps, 350 rpm; Skoda, 1909, 8 × 50R, 1885 fps, 420 rpm

    - Walter (2005): Caliber 8 × 50mm, weight of gun 15.5 kg, 575 m/s, 420 rpm
- Year: 1893
- Projmass: 16 g
- Velocity: 1805 fps
- Effrange: 800 m (assumed as contemporary Gatling guns and Maxim)
- Rate: 350 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 7; see Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS198: From US Marine Corps (USMC) (1998):

- pp. 4–7: HMG (meaning M2) squad, 4 enlisted.

MFS199:

From US Army (1937):

- 1937 US Army training film, 6 men in a squad for a HMG.

From US Army (1944):

- 1944 US Army training film, 3 men team for a HMG, 0.30-caliber Browning, water cooled.

MFS200:

- System: Pecheneg MG
- Sources:
    - TRADOC (n.d.; https://odin.tradoc.army.mil/WEG/Asset/PKP_Pecheneg_Russian_7.62mm_General_Purpose_Machine_Gun)
    - Wikipedia (2019j)
- Year: 2001

- Projmass: 7.62 × 54mmR
- Velocity: 900 m/s
- Effrange: 1500 m
- Rate: 800 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 2; see Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: see Note MFS170c

MFS201:

- System: MG3
- Source: TRADOC (n.d.; https://odin.tradoc.army.mil/WEG/Asset/Rheinmetall_MG_3_German_General_Purpose_Machine_Gun)
- Year: 1958?
- Projmass: 7.62 × 51mm NATO
- Velocity: 820 m/s
- Effrange: 600 m (bipod), 1200 m (tripod)
- Rate: 1300 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 2 for bipod, 4 for tripod; see Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: 3 kph; see Note MFS170c

MFS202:

- System: 0.50 Browning M2HB of 1930s

- Sources:
    - USMC (1996): Gun and tripod complete – 128 lb; MV – 3050 fps; maximum effective range 1830 m; cyclic rate 550 rpm; basic load of ammunition – 400 rounds; 100 rounds in ammo can – 35 lb. Also see Notes MFS198 and MFS199.
    - US Army (1933): The machine gun squad (cavalry) was 7 men.
- Year: 1933
- Projmass: 42 g
- Velocity: 3050 fps
- Effrange: 1850 m
- Rate: 550 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 6; compare to Note MFS174
- Sysmass: see Note MFS170b
- Offroad speed: 2 kph; see Note MFS170c

MFS202a:

- System: .50 Browning M2HB of 1970s
- Sources:
    - USMC (1996): Gun and tripod complete – 128 lb; MV – 3050 fps; maximum effrange 1830 m; cyclic rate 550 rpm; basic load of ammunition – 400 rounds; 100 rounds in ammo can – 35 lb.
    - Also see Notes MFS198 and MFS199.
- Year: 1970 *[Data compiler's note: I assume that reduced crew became common in late 1960s, early 1970s.]*
- Projmass: 42 g
- Velocity: 3050 fps
- Effrange: 1850 m
- Rate: 550 rpm

- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3 "The M2 0.50 caliber machine gun, employed on the M3 tripod, requires a crew of three to put it into action and keep it operating." p. 4-56. However, per US Army (1991), "with tripod the crew consists of 4 men; crew leader, gunner, assistant gunner, and ammunition bearer."
- Sysmass: see Note MFS170b
- Offroad speed: 2 kph; see Note MFS170c

MFS202a:

The USMC manual (see Note MFS202) indicates that M249 SAW is operated by a single rifleman.

MFS203:

- System: M240G
- Source: Note MFS202:
    - gun and tripod 45.6 lb; MV 2800 fps; max effrange – 1800 m; basic allowance – 400 rounds; weight of 100 rounds pack – 7 lb; max cyclic rate 950 rpm.
- Year: although it was designed in mid-1950s, here we consider it as it is used in mid-1990s.
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: "The machine gun squad consists of a squad leader and two 3-man machine gun teams. Each team operates one M240G and is composed of a team leader, a gunner, and an ammunition bearer" (USMC 1996).
- Sysmass: see Note MFS170b
- Offroad speed: assume slower than light infantry, 3 kph

MFS204: From Gudmundsson (1989):

- p. 100: The LMG squad with MG 08/15 consisted of 8 men, 1 gunner, and 2–3 ammunition and water carriers. The other 4 were riflemen; acted mainly as a maneuver element. So in practice only 4 of 8 were actually LMG crew.

MFS205: From McNab (2012):

- p. 38: As LMG, MG34 or 42 was served directly by a crew of 3, who were part of 10 men squad. The other men of the squad assisted when needed, but mostly were performing combat duties.
- p. 39: As HMG, these guns were a battalion asset, each served by six men: leader, gunner, assistant gunner, and three ammunition carriers.
- p. 42: Practical limit with iron sights fire was 800 m and 1500 m in a stretch. With optical sight to 3000 m.

MFS206:

- System: Tachanka w/ PM1910
- Source: Ganin (2017): Describes specifications established in 1926. Total weight of the carriage with people, weapons, fodder, ammunitions, and so on, 975 kg, with 4 horses and a crew of 3.
- Year: 1920
- Projmass: 0.0097 kg
- Velocity: 863 m/s
- Effrange: 800 m
- Rate: 550 rpm
- Protection: 160
- HP: 4
- Crew: 3
- Sysmass: 4 horses of 500 kg, pulling 975 kg; total 2975 kg.
- Offroad speed: I take the same assumption I make for horse artillery – 15 kph

MFS207: From Barker and Walter (1971):

- p. 8: Each rifle company of WW2 had a machine gun platoon, 16 men of 3 sections with one machine gun each, Maxim or SG.
- This implies a crew of 5.

MFS208: From RKKA (n.d.):

This Instruction for Infantryman refers to Maxim MG of 1931, and also refers to battles against “samurai and White Finns”, implying that it was composed right before WW2. It states that the crew of the HMG was the gun commander and 6 soldiers.

MFS209: From Williams (2013):

- pp. 10–11: Ford T model, 1200 lb, armored Rolls-Royce was 4 times heavier; 20-hp engine.
- p. 17: 100 miles per day.
- Lewis guns are mentioned predominantly (e.g., pp. 32, 37, 146, and 180), although there was one mention of Maxims.
- p. 74: 6-8 miles per hour.
- p. 97: 600 miles in 7 days.
- p. 143: 9 people in 4 cars.
- p. 172: 10 people in 4 cars.
- p. 173: 120 miles a day was easy going.
- p. 177: 120 miles per full day.
- p. 143: Example of load for 4 cars: 32 gallons water, 112 gallon petrol, rations for 5 days, 2 maxims, 2000 rounds ammunition, 9 people.

MFS209a:

- System: Ford T with Lewis MG
- Sources:
    - Note MFS209
    - Note MFS172
    - Hogg (2002): UK Lewis Mk 1, 1914, 25 lb, 2450 fps, 550 rpm
    - Wikipedia (2019d)
- Year: 1916
- Projmass: 0.0096 kg

- Velocity: 863 m/s
- Effrange: 600 m
- Rate: 550 rpm
- Protection: 160 J
- HP: 20
- Crew: 3
- Sysmass: 1200 lb plus payload (assume 1000 lb, considering that heavier Ford TT had the payload capacity of 910 kg; see Wikipedia [2019d])
- Offroad speed: 20 kph

MFS210:

[Data compiler's note: I limit my attention to the period when the use of technicals became a consistent paradigm (i.e., late 1970s [in Lebanon]). I also exclude weapons of caliber below 12.7mm, such as the PK-series weapons, as these do not appear to use the capacity of a light truck to the maximum, and it is better seen as simply a conveyance for light infantry with a crew-served weapon.]

From Neville and Dennis (2018):

- p. 13: Beirut in the late 1970s: the birthplace of the concept of the technical.

Most common direct-fire weapons:

- Russian DShK, 600 rpm, 1500 m effrange
- US 0.50 caliber M2, less commonly
- 14.5mm ZPU-1 and ZPU-2, less commonly ZPU-4
- 23mm ZU-23-2

Light technicals:

- Late 1970s, Beirut: Series III Land Rover and Toyota Land Cruiser with DShK, ZPU-1, and ZPU-2
- Circa 1984, Chad: Toyota Land Cruiser BJ-45, with up to ZPU-2?

Heavy technicals:

- Late 1970s, Beirut: Chevrolet C-20 with ZPU-4 *[Data compiler's note: Probably ZPU-2?]*

- 1993, Somalia, Unimog cargo truck, or Spanish Pegaso truck, with ZPU-4, or ZU-23-2
- 2015, Iraq, Syria: ad-hoc armored Ford F-350 Super Duty with ZPU-4

[Data compiler's note: I assume that with a heavy load of ammunition, water, fuel, and spare equipment, and with shield or other armor, and with heavy custom-made mounts, the nominal weight capacity of each truck was fully utilized. The crew, based on photographs, was typically three: gunner, assistant, and driver. With weapons of 12.7mm caliber and heavier, there was little or no room for riders in the truck bed.]

MFS210a:

- System: Land Rover Series III with DShK
- Sources:
    - Note MFS210
    - Wikipedia (2019i)
    - Year: 1978
- Projmass: 0.051 kg
- Velocity: 855 m/s
- Effrange: with ineffective platform, assume 50% of nominal – 1000 m
- Rate: 575 rpm
- Protection: 160 (no armor)
- HP: 86 hp
- Crew: 3
- Sysmass: max allowable weight 4453 lb
- Offroad speed: 20 kph

MFS210b:

- System: Land Cruiser BJ-45 with ZPU-2
- Sources:
    - Note MFS210

    - Wikipedia (2019m)
    - TRADOC (n.d., https://odin.tradoc.army.mil/WEG/List/Air_Defense&Anti-Aircraft_Guns&Light_Towed_Gun)
    - Wikipedia (2019g)
- Year: 1984
- Projmass: 0.060 kg
- Velocity: 1005 m/s
- Effrange: with ineffective platform, assume 50% of nominal 3000 m – 1500 m
- Rate: 1200 rpm (2 times 600 rpm of one barrel)
- Protection: 160 (no armor)
- HP: 80 hp
- Crew: 3
- Sysmass: assume 1 ton rating; curb weight 1480 kg; total 2480 kg
- Offroad speed: 20 kph

MFS210c:

- System: Chevrolet C-20 with ZPU-2
- Sources:
    - Note MFS210
    - TRADOC (n.d.; https://odin.tradoc.army.mil/WEG/List/Air_Defense&Anti-Aircraft_Guns&Light_Towed_Gun)
    - Wikipedia (2019g)
    - GM (1977)
- Year: 1978
- Projmass: 0.060 kg
- Velocity: 1005 m/s
- Effrange: with ineffective platform, assume 50% of nominal 3000 m – 1500 m

- Rate: 1200 rpm (2 times 600 rpm of one barrel)
- Protection: 160 (no armor)
- HP: 115
- Crew: 3
- Sysmass: assume 3/4 ton rating; curb weight 2040 kg; total 2790 kg
- Offroad speed: 20 kph

MFS210d:

- System: Ford F-350 Super Duty with ZPU-4
- Sources:
  - Note MFS210
  - TRADOC (n.d.; https://odin.tradoc.army.mil/WEG/List/Air_Defense&Anti-Aircraft_Guns&Light_Towed_Gun)
  - Wikipedia (2019g)
  - Wikipedia (2019e)
- Year: 2015
- Projmass: 0.060 kg
- Velocity: 1005 m/s
- Effrange: with ineffective platform, assume 50% of nominal 3000 m – 1500 m
- Rate: 2400 rpm (4 times 600 rpm of one barrel)
- Protection: ad-hoc armor, assume 3000 J
- HP: 300
- Crew: 3
- Sysmass: GVWR 3900 kg
- Offroad speed: 20 kph

MFS210e:

- System: 1993, Somalia, Unimog 404 with ZPU-4

- Sources:
    - Note MFS210
    - TRADOC (n.d.; https://odin.tradoc.army.mil/WEG/List/Air_Defense&Anti-Aircraft_Guns&Light_Towed_Gun)
    - Wikipedia (2019g)
    - Classic Unimogs (2010)
- Year: 1993
- Projmass: 0.060 kg
- Velocity: 1005 m/s
- Effrange: with ineffective platform, assume 50% of nominal 3000 m – 1500 m
- Rate: 2400 rpm (4 times 600 rpm of one barrel)
- Protection: 160 (no armor)
- HP: 110
- Crew: 3
- Sysmass: assume it is Unimog 404, a particularly common, offroad version. Its gross vehicle weight rating (GVWR) is 5000 kg.
- Offroad speed: 20 kph

MFS210f:

- System: 1993, Somalia, Unimog 404 with ZU-23-2
- Sources:
    - Note MFS210
    - Classic Unimogs (2010)
    - TRADOC (n.d.; https://odin.tradoc.army.mil/WEG/List/Air_Defense&Anti-Aircraft_Guns&Light_Towed_Gun)
- Year: 1993
- Projmass: 0.18 kg
- Velocity: 970 m/s

- Effrange: with ineffective platform, assume 50% of nominal 2500 m – 1250 m
- Rate: 2000 rpm
- Protection: 160 (no armor)
- HP: 110
- Crew: 3
- Sysmass: assume it is Unimog 404, a particularly common, offroad version. Its GVWR is 5000 kg.
- Offroad speed: 20 kph

MFS212:

- System: STK 50MG
- Sources:
    - Hogg and Weeks (2000): STK 50MG: 30 kg, 600 rpm, MV 890 m/s
    - Wikipedia (2019l)
    - Also see Note MFS202a.
- Year: 1989
- Projmass: 42 g
- Velocity: 890 m/s
- Effrange: assume same as M2HB – 1850 m
- Rate: 600 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 3 (assume same as M2HB)
- Sysmass: see Note MFS170b
- Offroad speed: 2 kph

MFS213:

- System: Hotchkiss 13.2 × 99, and Breda 31

- Source: Wikipedia (2019f)
- Year: 1929
- Projmass: 52 g
- Velocity: 800 m/s
- Effrange: assume same as M2HB – 1850 m
- Rate: 450 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 6 (assume same as M2HB of 1930s)
- Sysmass: see Note MFS170b
- Offroad speed: 2 kph

MFS214:

- System: Vickers 12.7mm
- Source: Fedorov (1939)
- Year: estimated 1927
- Projmass: 37 g
- Velocity: 778 m/s
- Effrange: assume same as M2HB – 1850 m
- Rate: 600 rpm
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 6, see Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: 2 kph; see Note MFS170c

MFS215:

- System: Fiat 12mm 1926

- Source: Fedorov (1939)
- Year: 1926
- Projmass: 40 g
- Velocity: 940 m/s
- Effrange: assume same as M2HB – 1850 m
- Rate: 600 rpm (Fedorov does not provide the number; I assume similar to contemporary Vickers 12.7; see Note MFS214)
- Protection: 160 (unarmored infantry, no shield)
- HP: 0.1 hp times the number of crew
- Crew: 6, see Note MFS170a
- Sysmass: see Note MFS170b
- Offroad speed: 2 kph; see Note MFS170c

MFS216:

Having revisited the data for towed artillery for the period of 1550–1700, I felt some adjustments were necessary:

- Regarding the muzzle velocity, the lowest number suggested by Note MFS057 is 344 m/s. I accept it uniformly for the period. It cannot be too far from truth, considering that in mid-1800s the muzzle velocity was on the order of 450 m/s.
- Regarding the rate of fire, Note MFS052 mentions the rate of fire of 15 shots per hour, in the mid-1600s. This number was probably limited by the fear of overheating and over-stressing the gun, not by the speed of reloading.
- Note MFS057: In the 18th–19th centuries, 2 solid shots per minute was maximum.
- Note MFS148: In the mid-to-late 1700s and early 1800s, up to 9 rpm was possible for a short period of time. With such a range of possible numbers, I take 1 rpm as a plausible assumption for the entire period of 1550–1700.

MFS217: From Hunnicut (1978):

- p. 525: Sherman M4A2: first acceptance April 1942; apparently the largest production of all Shermans with 75mm gun; Sherman M4A3(76)W – March

1944, largest production volume of all 76mm gun tanks; 90mm GMC M36 – April 1944; most numerous of M36's.

MFS218:

- System: Sherman M4A2
- Sources:
  - Note MFS217
  - Hunnicut (1978): pp. 542, 562
- Year: 1942
- Projmass: based on 75mm gun M3, APC M61 projectile – 14.96 lb
- Velocity: 2030 fps
- Effrange: 2000 yd
- Rate: 20 rpm
- Protection: assume roughly consistent with muzzle KE of Panzer IV, on the order of 2 MJ
- HP: 375 hp
- Crew: 5
- Sysmass: 70200 lb
- Offroad speed: 12.5 mph, assume 50% of speed at level road stated as 25 mph

MFS219:

- System: Sherman M4A3(76)W
- Sources:
  - Note MFS217
  - Hunnicut (1978): pp. 546, 564
- Year: 1944
- Projmass: based on APC M62, 15.44 lb
- Velocity: 2600 fps

- Effrange: 2000 yd
- Rate: 20 rpm
- Protection: assume roughly consistent with muzzle KE of Panzer IV, on the order of 2 MJ
- HP: 450 hp
- Crew: 5
- Sysmass: 74200 lb
- Offroad speed: 13 mph, assume 50% of speed at level road stated as 26 mph

MFS220:

- System: M36 Tank Destroyer
- Sources:
  - Note MFS217
  - Hunnicut (1978): pp. 553, 567
- Year: 1944
- Projmass: assume APC M82 – 24.11 lb
- Velocity: 2800 fps
- Effrange: 2000 yd
- Rate: 8 rpm
- Protection: assume somewhat lower than what would correspond to the muzzle KE of Panzer IV, on the order of 1.5 MJ
- HP: 450 hp
- Crew: 5
- Sysmass: 63000 lb
- Offroad speed: 13 mph, assume 50% of speed at level road stated as 26 mph

MFS221:

- System: Sherman Firefly
- Source: Hunnicut (1978): pp. 308, 550, 565

- Year: 1944
- Projmass: assume APCBC-T– 17 lb
- Velocity: 2900 fps
- Effrange: 2000 yd
- Rate: 10 rpm
- Protection: assume somewhat lower than what would correspond to the muzzle KE of Panzer IV, on the order of 1.5 MJ
- HP: 370 hp
- Crew: 5
- Sysmass: 72100 lb
- Offroad speed: 10 mph, assume 50% of speed at level road stated as 20 mph

4. Conclusions

The additional data presented in this report expand the data set of ARL-SR-0417 (Kott 2019a) by approximately 50%. Among other additions, two classes of systems have been added: crews with machine guns and crewed "technicals". The added data are highly consistent with the previous data, as illustrated for example in Fig. 1. All conclusions of ARL-SR-0417 apply here as well.

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List of Symbols, Abbreviations, and Acronyms

AP	armor-piercing
CCDC ARL	US Army Combat Capabilities Development Center Army Research Laboratory
CE	common era
DOD	Department of Defense
effrange	effective range
FoM	figure of merit
GVWR	gross vehicle weight rating
HAI	heavy armored infantry
HA	horse artillery
HMG	heavy machine gun
KE	kinetic energy
LAI	light armored infantry
LMG	light machine gun
LNI	light infantry without armor
m	mass
MAI	modern infantry that uses body armor
ME	muzzle kinetic energy
MFS	ground-mobile, direct-fire systems
MV	muzzle velocity
NATO	North Atlantic Treaty Organization
projmass	projectile mass
pdr	pounder
SP	self-propelled
sysmass	system mass
V	velocity

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