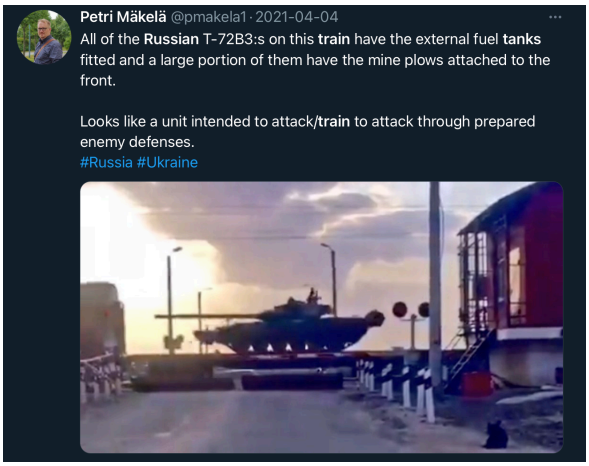
Battle along the Dnieper

Modelling a Russian Invasion of Eastern Ukraine

Russian cargo trains kept busy in April, their movements tracked by social media users. A steady steam of uploaded videos detailed wagons loaded with heavy armour rolling towards the Ukrainian border. Defence observers noticed this as well. Ukrainian officials estimate Moscow moved forward some 110,000 troops as part of its “snap drill”, the largest concentration of Russian forces along Ukraine’s border since 2014.



The escalation unnerved capitals across Europe, set Ukrainian forces on high alert, and led to preparation of Kiev’s extensive network of air raid shelters. Ukraine’s president, Volodymyr Zelensky, took to the airwaves to warn the Ukrainian public that war with Russia was possible. Not since the seizure of Crimea by Russia’s ‘little green men’ and the eruption of war in the Donbas seven years ago have prospects for large-scale war in the region looked so dire.

A Dog to be Wagged

Why the buildup? As is typically the case, there is a confluence of factors at play.

First is Russia’s already shaky Crimean occupation has struggled with a catastrophic water shortage. The problem began in 2014, when Ukraine shut off the North Crimean Canal, a 400-km Soviet-era channel that diverted the mighty Dnieper to the peninsula’s arid steppe. With limited rainfall and Ukraine blocking the canal—which once provided 90% of the region’s freshwater—reservoirs have shrunk to almost nothing (the reservoir at Simferopol is just 7% full) and desertification looms; already arable land has shrunk from 130,000 acres to 14,000. With Ukrainian promises to turn the water back on yet to materialize, Russian officials have been forced to rely on increasingly desperate measures, including digging wells, desalinization schemes, attempts to buy water from Ukraine, and, now, water rationing—all of which have come to naught.

Second is the need for Russia to push back against the increasingly hard line espoused by the new American president. In a March television interview, President Biden—someone long critical of Russia’s current ruling class—agreed that Putin was a “killer” and pledged that the Russian President “was going to pay” for Russian interference in the 2020 US election. Earlier in the month, the Biden administration announced sanctions against Russian officials in

response to evidence that Russian agents had poisoned the opposition leader Aleksei Navalny. Meanwhile, Secretary of State Antony Blinken has come out in opposition to the $11 billion Nord Stream 2 pipeline, being built by Gazprom to deliver Russian natural gas to Germany.

This harder line has raised hackles across Russia, encouraging Russian policymakers to adopt a more belligerent tone. The Russian ambassador to America was recalled for the first time since 1998. Pyotr Tolstoy, deputy chairman of the lower house of Parliament, recently declared that "the only language" that Americans understand "is, unfortunately, the language of force." And from the president himself, a warning: "We know how to defend our interests."

Third, and most important, are the fractures starting to show in Putin's domestic power base. Navalny's combination of courage in the face of constant attempts to murder him, and steady spotlight on the graft and corruption permeating the Putin regime have encouraged tens of thousands of Russian citizens to express their displeasure with the recent fall in living standards and the state's increasingly naked authoritarianism by taking to the streets. An estimated half of all young people aged 18-24 disapprove of the president, a historic high. Disapproval amongst the public more generally is now up to 35%, a level not seen since before Crimea's seizure—a gambit, we should remember, that gave Putin an immediate and decisive ratings boost.

Putin's grip on power has never looked so weathered and out-of-touch. His coterie feels bullied and belittled by the West. Crimean crops are withering on the vine. This provides ample incentive for Russian sabre-rattling, particularly since military adventurism is something Putin has used to shore up domestic support in the past.

Build-up on the Steppe

In order to fully understand the nature of the Russia threat, we first must consider the potential costs and benefits of military force. Doing so is as much alchemy as it is science, but by modelling the problem in a rigorous and systematic fashion we give ourselves a much better chance of properly appreciating the gravity of the risks involved.

In this brief we rely on a simplified "attrition-FEBA [forward edge of the battle area] expansion" model, as formulated by Richard Kugler and popularized by Michael O'Hanlon.[1] Historical data for many of the key assumptions come from Trevor Dupuy and James Dunnigan.[2] Current force dispositions rely on public sources and therefore are likely subject to a good deal of error. Nevertheless, the construction of the model and the values chosen are ultimately—for good or ill—the responsibility of the author.

Order of Battle

The best way to measure the combat strength of a buildup this size is to start with a battalion count for each belligerent. For this we took the 2014 Russo-Ukrainian crisis deployment data collected by the *Washington Post* and scaled it up to reflect the 110,000 Russian troops

[1] See Barry R. Posen, "Measuring the Conventional Balance", p79-120 and Michael O'Hanlon, *The Art of War in the Age of Peace*.

[2] Trevor Dupuy, *Understanding War* (Nova, 1998). A good survey of his findings is available here. Christopher Lawrence's *War by Numbers* (University of Nebraska, 2017) follows in Dupuy's footsteps. James F. Dunnigan's *How to Make War* (William Morrow, 2013) is another helpful source for combat modellers.

estimated by defence officials in Kiev.[3] Doing so gives us a total of 95 in-theatre Russian battalions and 88 Ukrainian, broken into the following types:

BATTALION COUNT

Formation	Armour	Motor Rifle / Mechanized	Airborne / Air Assault	Light Infantry / Reserve	Special Forces	Recce
Total: Russia	20	36	25	0	9	5
Total: Ukraine	19	41	24	0	4	0

With these numbers we can estimate the number of local- and American-style divisions, the latter of which make formations from different militaries comparable:

DIVISIONAL EQUIVALENTS

Battalions per Division	12
A: Russia	7.9
B: Ukraine	7.3

US DIVISION EQUIVALENTS

US or Russian ADE?	0.7
A: Russia	**5.5**
B: Ukraine	**5.1**

We can then convert these raw figures into assumptions about vehicles and troop counts. As shown in the table below, the total number of soldiers roughly reflects the public intelligence:

TOTAL ASSUMED VEHICLES

	Russia	Ukraine
US or Russian Size?	Russia	Russia
Armoured Vehicles	50	50
Troops /Battalion	600	600
Troops /Division	14,000	14,000
Trucks	1,500	1,500
Tanks	1,000	950
IFVs	1,800	2,050
Trucks	11,875	11,875
Combat Troops	57,000	52,800
Total Troops	110,833	102,667

Finally, we adjust the US or 'Armoured Division Equivalent' (ADE) standard by relative equipment performance, or weapons capability ratio (WCR). Because Russian equipment is tends to be newer than Ukrainian, we inflate Russia's ADE total by a factor 1.1 to account for their superior weapons.

[3] This is in addition to the estimated 30,000 paramilitary separatist forces holding the breakaway regions of Donetsk and Luhansk in eastern Ukraine.

Coming up with an estimate of close support aircraft is more difficult, given there is less publicly available information regarding aircraft deployment. We can, however, use Russia's deployment to Syria[4] as a template. In 2018 the Russian Defence Ministry released data indicating a sortie rate of 37 flights per day. This number can reasonably be scaled this to 200-250 attack aircraft in a Ukrainian theatre of operations.

For the purposes of this paper we ignore naval combat, since Ukrainian forces are so weak—though it is reasonable to expect Russian cruisers would shell positions inland from the Black Sea, as well as ferry troops across the Azov to flank Ukrainian positions on the southern coast. Such movements would likely be catastrophic for *local* defenders, but excluding the modest numbers of cruisers and landing craft from our model does not detract from its central conclusions.

RAW COMBAT STRENGTH

	A	B	A:B WCR
Troops Deployed	110,833	102,667	1.0
Armoured Fighting Vehicles (AFV)	2,800	3,000	1.1
Close Support Aircraft	225	50	1.1
Armoured Division Equivalent (ADE)	**5.5**	**5.1**	***1.1***
ADE - *Adjusted* for Equipment	**6.1**	**5.1**	***1.2***

Quality of Forces and Operational Factors

Raw numbers, of course, provide no guarantee of operational performance. Troop quality, environmental conditions, and considerations like force posture, air superiority, and surprise play a significant role in determining how effective military forces will be.[5]

To account for quality in our model we assign a value for combat effectiveness (CEV), a measure that incorporates elements like leadership and training. Here we assign roughly equal values, in part because of the shared cultural, doctrinal, and technological roots of the once-united militaries. This also reflects the fact that the gains from Russia's extensive military modernization programme have been at least partially offset by Ukraine's own crash program[6], as well as the multinational (including Canada) effort to rebuild its armed forces. For clarity, Russia is the attacker in this scenario.

COMBAT EFFECTIVENESS

CEV	Attacker	Defender
Leadership	1.1	0.9
Morale	1.0	1.0
Training	1.0	0.8
Experience	1.0	1.0
Manpower Quality	1.0	1.0
Readiness	1.1	0.8
Net CEV	**1.0**	**0.9**

[4] With 62 close air support aircraft recognized in news releases collected by Wikipedians here.

[5] Trevor Dupuy's work has been particularly valuable in and the work that follows is heavily indebted to both him and James Dunnigan.

[6] These efforts followed the catastrophic loss of its territory 2014. The Ukrainian defence budget, for example, jumped from 1.5% of GDP in 2010 to 3.4 in 2019.

For historical comparison of these values, see the following tables:

HISTORICAL CEV

	Vs Allies	Vs Russia	Vs Germany	Vs Japan	Vs Arabs
Germany WWII	1.2	2.3			
US WWII			0.8	1.5	
Israel Arab Wars					2.0

ROUGH CEVS

Untrained Militia	0.1
Green Troops	0.5
Average Troops	1.0
Crack Troops	1.2
Elite Troops	1.5

For terrain effects we assume—as will be discussed below—any Russian advance would halt a the Dnieper river, suggesting the predominant battle terrain will be open and flat. As evidenced by the titanic tank battles that took place in the region (such as Kharkov 1943, Kursk 1943, and Korsun-Cherkassy 1944), the region favours mobile warfare.

For weather we assume clear weather and no aircraft groundings, with no bias towards either the attacker (Russia) or defender (Ukraine).

Operationally, we can expect well-fortified Ukrainian positions, given the two sides have been locked in a stalemate since 2014. This would significantly reduce the effect of Russian attacks.

Given the size and improving capacity of the Russian air force, it is reasonable to expect Russia would achieve complete air superiority in a matter of days. Ukrainian airframes are just too old and too few to mount a sustained challenge to Russian air power.

Last, Russia's traditional strength of masking operational intent from prying eyes makes the prospect of at least some surprise very real. That said, given Ukraine's access to NATO's surveillance intelligence, we should expect this effect to be partial at best.

Summing the average of each of these elements provides a net environmental and operational factor. We can then take this figure, apply reasonable estimates about aircraft and armoured vehicle readiness, and then adjust for the CEV, to give a Net Factor to apply to our calculated raw combat power value. These calculations are summarized here:

ENVIRONMENTAL & OPERATIONAL FACTORS

Environmental	Condition?	Attacker	Defender
Terrain			
-Flat	✓	0.9	1.1
-Mixed (ie Ardennes & NE France)		0.8	1.3
-Rugged (ie Vosges mountains)		0.7	1.5
-Urban		0.7	1.5
-Beach		0.5	2.0
Weather			
-Clear	✓	1.0	1.0
-Rain		0.8	1.2
-Cold & Snow		0.8	1.3
Operational			
Posture			
-Open		1.0	1.0
-Hasty Defence		0.8	1.3
-Prepared		0.7	1.5
-Fortified	✓	0.6	1.6
Air Superiority			
-Indecisive (ie Europe 1940)		1.0	1.0
-Raids Opposed (ie Europe 1943)	✓	1.3	0.8
-Skies Cleared (ie Gulf War)		1.7	0.6
Surprise			
-None		1.0	1.0
-Partial	✓	1.3	0.8
-Total		1.5	0.7
Net EvOp Factor	✓	**1.0**	**1.0**

FACTORS AFFECTING COMBAT POWER

Environmental		
Terrain	Flat	
Weather	Clear	
Aircraft Weather Groundings	0%	0%
Operational	**A**	**B**
Aircraft Readiness Rate	60%	50%
Armoured Vehicle Readiness	90%	90%
Net Env & Operational Factor	1.0	1.0
Combat Effectivness	**A**	**B**
CEV	1.0	0.9
Net Factor	**1.1**	**1.0**

The result is to increase the Russian ADE value, adjusted for equipment, by a further 10%. Adjusted Russian power therefore rises from 6.1 to 6.5 ADEs. Meanwhile, Ukraine's figure is reduced by a little less than 5%, bringing total Ukrainian ADEs to 4.9. This is a relative power differential of 1.3, suggesting that in all but a grossly mishandled offensive would Russia emerge as the winner.

GROUND COMBAT

	A	B
ADE-Adjusted * Net Factor	6.5	4.9
A:B Relative Power	1.3	

Battle Plans

Before modelling a prospective Russian attack, we first need to consider *how* these forces might be deployed. A Russian strike on Ukraine could take several forms. Regular forces could attempt a breakout of the Donbas pocket, where separatist forces (and Russian reinforcements) have been sealed in since the 2014 uprising. The objective here would be to capture the remaining portion of Donetsk and Luhansk oblasts still in Ukrainian hands, and perhaps to take the important port city of Mariupol.

More ambitious would be a westward offensive out of the Donas pocket, leaving the north untouched but marching in the south all the way to the Dnieper.[7] This would establish a 450km 'land bridge' between separatist forces in the Donbas and Russian positions in Crimea. It would avoid the larger cities of Kharkov, Poltava, and likely Zaporizhia, but nonetheless take a large enough slice of southern Ukraine to retake the North Crimean Canal and permit water to once again flow to the parched Crimean peninsula.

Of these two options, neither is particularly appealing. A push by regular forces to make a small inroads in the highly-populated but poor Donbas would cause more political headache than it would be worth. Unleashing regular forces—and all the public relations complications that brings—without being able to eventually deliver a decisive victory that would give Moscow political cover, does not sound like a winning bet.

The land bridge scenario offers the prospect of tangible gains, both politically and in terms of easing the administration of Russia's newest autonomous region. But from a military standpoint it suffers from a grave disadvantage: a narrow band of territory across a long front without much in the way of defensive geography is ripe for counter-offensive. If Zaporizhia was not taken, it could be used to stage a drive south, intent on splitting the Russian incursion in half. More than a dozen crossings over the Dnieper north of the 'bridge' would remain in Ukrainian hands, supporting the buildup necessary to achieve this. It is therefore easy to imagine extreme reticence on behalf of the Russian general in charge of putting this option forward.

The only strategically defensible Russian strategy would be to split Ukraine down the middle, seizing everything east of the Dnieper. The river—one of the mightiest in Europe—would then anchor a 900km-long defensive line that would be extremely difficult for whatever Ukrainian forces survive the initial assault to retake. The conquest would add some 350km to Russia's strategic depth, long a preoccupation of military planners in Moscow (and St. Petersburg

[7] A more ambitious version of this strategy would be to cross the Dnieper, take Odessa, and continue all the way to the Moldovan break-away republic of Transnistria. This option is even less likely, however, because because of the difficult river crossing as well as the long, exposed flank on the Dnieper's right (west) bank—a position ripe for encirclement.

before that). Such a move would also, by handing a half-dozen hydroelectric stations into Russian hands and severing from Kiev almost half the country's population, end any serious Ukrainian threat to Russian interests in the region.[8]

Battle Forecast

If Moscow decides to gamble on a large-scale military invasion, the least-risky, most-decisive option will be preferred. As such, it is the 'Eastern Ukraine' scenario we model here.

The Air War

With such a commanding Russian presence in the sky, the outlook for Ukraine's air war looks bleak. Taking our assumed numbers of close air support aircraft—which may be somewhat conservative—and a daily sortie rate of 1.5 flights per aircraft (for Western planes in good condition we should expect around two; Russian and Ukrainian equipment would be somewhat more unreliable) gives us a rough base line of daily combat potential. Of these flights, we estimate a 2% loss rate for Russian planes to air and ground fire. For Ukrainian planes we estimate 4%, once again because the plethora of air superiority aircraft and surface-to-air missiles Russia would deploy, making the airspace extremely dangerous for their former comrades.

If each sortie can fire three precision-guided missiles per flight (slightly less for the older Ukrainian weaponry) with a kill probability of around 30% and each sortie discovering a target 10% of the time, we should expect 18 daily aerial kills (roughly half in armoured vehicles and half in trucks and other equipment) for the Russians and just 3 for Ukraine.

AERIAL BOMBARDMENT

	A	B
Daily Sortie Rate	1.5	1.5
PGM Munitions Per Sortie	3.0	2.7
Kill Probability Per Munition	30%	28%
Air- & Ground-Defence Aircraft Loss Rate	2%	4%
Target Discovery per Sortie	0.1	0.1
Total Daily Kills	18	3

[8] This would not be Ukraine's first partition along the Dnieper. In 1667, the left (east) bank was split from the Polish-Lithuanian Commonwealth and handed to Russia at the conclusion of the 13-year Russo-Polish War. This period in Ukrainian history is known as 'The Ruin'.

Ground Combat

Estimating the cost of the land war first requires assuming a daily combat loss rate. Dupuy and O'Hanlon offer some historical comparisons in the table here, but the typical value for modern combat is around 2%. For this exercise we assume a Russian loss rate of 2% day, with a Ukrainian value of 2.5%. The higher number is to reflect the fact Ukrainian forces will almost certainly be—outside NATO intervention, which should be considered unlikely—operating in an environment of almost complete Russian air superiority. Both forces should, nonetheless, fight hard and reasonably well, preventing a catastrophic rout.

DAILY LOSS RATES

	Daily Loss Rate	
Army - US in Gulf 1991	0.1%	O'Hanlon
Army - Israelis 1973	1.8%	Dupuy
Army - Egyptians 1973	2.6%	Dupuy
Army - Syrians 1973	2.9%	Dupuy
Army - Iraqis in Gulf 1991	3.0%	Dupuy
Army - Egypt in 1967	6.0%	Dupuy

Calculating total losses from an order of battle and daily loss rates needs an expectation of how long the struggle is going to last. There are two ways to do this. First is to infer a daily advance rate given battlefield terrain, current technology, and the disposition of forces. Eastern Ukraine is tank country, with Russian armour supported by plenty of air support and boasting a significant power advantage. Inferring from Lawrence's historical data in the table below, we assume a Russia advance rate in the neighbourhood of 6-10km per day. We can take the upper number of this and divide it by the drive distance required to bring about at least a tactical victory. Since the strategic objective assumed above is around 350 km in distance, a reasonable guess is the invasion would last a little over a month.

ADVANCE RATES

Lawrence, *Numbers* p179-80	Km/day
1600-1900	1.1
1904-1918	2.3
Meggido (1918)	35.0
1938-1945	2.9
1st US Cav Philippines (1945)	75.0
Arab-Israeli Wars (1956-1973)	6.3
Gulf War (1991)	27.4
Iraq War (2003)	-
3rd Mech Inf March to Baghdad	32.0
Once reach Baghdad (7 days)	3.2

DAY CALCULATOR

Max Depth (km)	340
Assumed Advance Rate (km/day)	10
Days Required to Complete Depth	34.0

50% POINT

A Power ADEs Reach 50%	38
B Power ADEs Reach 50%	26
1st to Capitulate:	B

The second method is to apply the daily combat loss rates to the (unadjusted, to allow for accurate casualty counts) ADEs for each belligerent, then plot out an attrition curve that shows when combat power is ground down to less than 50% of initial capacity, which is a reasonable point to assume *battle* capitulation.[9] With this method Ukrainian power falls below the 50% threshold after 26 days of high intensity combat. Russia, by contrast, does not reach this number until 38 days, which suggests their frontline formations can hold out for roughly two weeks longer (in the absence of reinforcement) before capitulating. Russia, therefore, is expected to be the victor.

[9] This is an important distinction. This model is a technique for forecasting *battle* outcomes, not war.

Since both duration methods give us roughly the same result, we can safely conclude the month estimate here is not an unreasonable one to make. To err on the side of caution[10] we use the lower number of fighting 26 days. Aerial losses are calculated using this number as well. When added to the non-adjusted ADE loss figures we get total expected ADE losses.

Daily Combat Loss Rate (ADE)	2.0%	2.5%
Fighting Days	26	
Total Losses from Aerial	71	464
Aerial ADE Loss Equivalents	*0.04*	*0.23*
Total Non-Adjusted ADE Ground Losses	*2.88*	*3.34*
Total ADE Losses	**2.9**	**3.6**

Using a rough killed-to-wounded ratio assumption we can convert expected ADE losses into casualty figures. The lesson is that while relatively short, the campaign would inflict battle casualties the likes of which Europe has not seen in more than a generation.

INFERRED LOSSES

	Killed	Wounded	Assumed K:W
A	10,502	42,007	20%
B	19,272	44,968	30%

More ominously, it is important to remember that this model details the initial battle of a Russo-Ukrainian conflict, not a long term *war*. The implication is that while the Russians are more than likely to win an opening contest—in the absence of heavy reinforcements from Ukraine's allies—once this engagement comes to an end the frontline may stabilize and the war could go on. Even more, Ukraine's inability to mount a serious counter-offensive would lead to calls for peace, but any delay would embolden the inevitable pro-Ukrainian insurgent operations happening behind Russian lines. The body count would then continue to grow.

Conclusions

There are are three central conclusions to be drawn from this exercise:

1. The only reasonable large-scale Russian invasion plan is to 'go big' and strike across eastern Ukraine all the way to the Dnieper. Limiting offensive scope to the south risks long supply lines and unfettered access to Russian positions by Ukrainian partisans and counter-offensives.

2. Russia has sufficient combat power to capture eastern Ukraine, and to do so in about a month.

3. The cost to Russia, however, would be significant. Three heavy armoured division equivalents would be destroyed—a substantial fraction of the country's front-line combat power, leaving it weak on other fronts. The battle would also claim more than 10,000 Russian lives and another 40,000 wounded.[11] No amount of stage-managing could hide the magnitude of this toll from the Russian people.

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[10] In terms of casualties, at least.

[11] For contrast, the 1979 to 1989 Afghanistan War cost 15,000 Russians killed and another 35,000 wounded.

Moscow is not ignorant of this calculation. It is likely because of this, rather than some loss of faith in the utility of force, that soon after Russian force numbers reached their peak the Russian defence minister announced his troops would begin to be draw-down. The only good option, in other words, is not good enough.[12]

There is an important lesson in here for policymakers as well. For all the importance of Washington conveying high-level warnings to Moscow of the "costs and consequences" of further aggression, what ultimately matters is the damage Ukrainian forces can inflict on advancing Russian tank columns. Any assistance the United States and its like-minded allies can provide regarding this is therefore to be welcomed.

[12] This view is of course not universally held. Ben Hodges of the Center for European Policy Analysis, for example, argues that "the Kremlin is intent on war with Ukraine because Russia is increasingly confident that the West will not actually do anything about it." The argument in this brief, by contrast, is that it is not the prospect of Western intervention that keeps Russia at bay, but instead that for all their flaws, Ukraine's tanks and artillery would inflict sufficient harm that even a victory would feel for Putin like a loss.