



KING ETHELRED'S COLLEGE OF ENGINEERING

Established in 978 (ish)

DEPARTMENT OF AERONAUTICAL ENGINEERING
AND APPLIED FLUID MECHANICS

SOME ASSEMBLY REQUIRED: A RUSSIAN DRONE, FIFTY-FIVE PARTS, SEVEN COUNTRIES AND ONE STOOL

Being an account of a Geran-4 jet-powered attack drone delivered to the College in error, taken apart on the workshop bench, weighed against its published specification, and returned to its component countries in the form of a bill



A departmental research thesis prepared under the College Fellowship Ordinance
(Objects Delivered Without Explanation, and the Counting Thereof)

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*Fortitudine.
Ingenio.
Tea and biscuits.*



ABSTRACT

On Monday 21 September 2026 a crate followed the College signpost marked 'Deliveries' to the workshop, where all three of its arms point, and was signed for. It contained a Geran-4, the jet-powered attack drone that Russia has been flying against Ukraine since May 2026, with its airframe complete, its engine in place, its warhead absent and its paperwork limited to a label. The College does not know who sent it and has asked. The Bursar has entered it as 'donation, unsolicited, airframe, one'. This paper is what the Department did with it, which was to take it apart on the bench, count what it found, compare the count with what Ukraine's Defence Intelligence has published from the wreckage of real ones, and put it in the wind tunnel to see whether it was subsonic. It was.

The real record is this. The Geran-4 is the third jet in a family that began as the Iranian Shahed-136, a propeller drone of 185 km/h that Russia bought six thousand of in 2022 at \$193,000 each and now builds itself at Alabuga in Tatarstan for a fraction of that.[1,6,8] Ukraine's Defence Intelligence lists 55 identified components in the Geran-4 by maker and country: 24 from the United States, 15 from China, two each from Germany, Japan and Great Britain, one each from Taiwan and Switzerland, and eight not identified. Texas Instruments alone accounts for twelve.[3] The engine is Chinese, the camera is Chinese, the mesh modem is Chinese, the tracker carries mobile-telephone modems and a Raspberry Pi, and what is Russian, the specialists who took a real one apart say, is mainly the body and the assembly.[2,3] The Geran-5 that followed it in 2026 is intercepted about 60 per cent of the time, against 95 for the propeller types, and Ukraine is using fighters and running short of the missiles that can catch it.[1]

The College's findings are in Chapter 8. The shortest is that the drone has more American parts than Chinese ones and two British ones, and that Miss Catchpole has filed the Raspberry Pi under 'Apparatus, British, abroad'. The longest concerns the rate of production, which the Bursar has compared with the College's and declined to comment on further.

Research status. The Geran family, its specifications, Ukraine's component lists, the interception rates, the prices and the production figures are real and referenced. Where sources disagree the paper gives all of them and says which it used. The crate, its arrival, the College's teardown, the wind-tunnel run, the Bursar's card and the Department's interceptor trials are fiction and are marked as such. Nothing was flown, launched or fitted with a warhead. The College is fictional; the drones, and the people under them, are not, and the paper does not joke about them.

Keywords: Geran-4, Shahed-136, one-way attack drone, turbojet, bill of materials, sanctions, Alabuga, interception, Raspberry Pi, Gerald's connector.

ACKNOWLEDGEMENTS

The Department thanks the Porters' Lodge, which signed for the crate and would like it recorded that the signature is not an acceptance of liability, a legal position the porter arrived at without advice.

Mr Arthur Stobbs, Clerk of Works, was asked what became of the four litres of fuel drained from the tank. He said it went where the College's water goes, and that he would be checking the grating.

Miss Honoria Catchpole of the Æthelred Library of Useful Numbers catalogued the parts as they came off the bench, on tie-on labels, in the order removed, and has asked that the paper's Table 4.2 be regarded as a copy of her catalogue and not the other way round.

Professor Cuthbert Widdowson-Bligh, Chair of Large Numbers and Difficult Formulae, was shown three published top speeds for the same drone. His written comment is reproduced in full in Chapter 2.

Major (Retd.) Alistair MacTavish was asked, without being asked, for his view on interception. It is in Chapter 6, and does not involve moving.

Mrs Enid Partridge of the Senior Common Room was told that the drone carries SIM cards from four countries so that it can be tracked over the mobile-telephone network. She said the urn had managed on one element since 1962 and had never needed to ring anybody.

The Department of External Procurement, Regime Restoration and Unintended Consequences read the bill of materials at the Department's request and returned it with one word on the cover. The word is in Chapter 5.

Gerald was not consulted. A connector on the engine's control loom did not match anything on the bench. The one in the shoebox under his desk did.

Statement on nomenclature. 'Geran' is the Russian service name of the family, from the geranium; the Iranian original is the Shahed-136. 'HUR' is Ukraine's Defence Intelligence, whose War & Sanctions site publishes the component lists. 'The crate' means the one that arrived; 'the drone' means what was in it; 'the bench' means the workshop bench, at Gerald's end. 'Subsonic' means slower than sound, which the Department confirmed at some expense.

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NOMENCLATURE

Symbol	Meaning
Alabuga	The special economic zone at Yelabuga, Tatarstan, founded 2005, where Russia builds Gerans
Borscht	The Geran-4's tracker: mobile-telephone modems and a Raspberry Pi, so the operator knows where it is
CRP antenna	A controlled-reception-pattern satellite-navigation antenna that ignores jamming from the ground
Geran-2	The propeller Shahed-136 as built in Russia: 185 km/h, up to 2,500 km, a piston engine
Geran-4	The subject: turbojet, 3.6 m long, 3.05 m span, up to 450 kg, 50 kg warhead, 770 km, 320 km/h cruise
Geran-5	The successor: 6.5 m, 850 kg, 90 kg warhead, 950 km, up to 600 km/h; intercepted 60 per cent of the time
HUR	Ukraine's Defence Intelligence, and its War & Sanctions component lists
Mach number	Speed divided by the speed of sound. The Geran-4 at cruise: about 0.26
Mesh modem	A radio that talks to other drones so that several can relay a signal 300 km back to an operator
One-way attack drone	A drone that does not come back. The Department has noted the design economy
Shahed-136	The Iranian original: sold to Russia in 2022 at \$193,000 a unit, six thousand of them
Telefly	A Chinese company whose turbojets power the Geran-3, -4 and -5
The shoebox	Under Gerald's desk. Where connectors are found
The Tunnel	The Sir Barnes Wallis Subsonic Wind Tunnel, which is subsonic, and so was the drone

1 INTRODUCTION

1.1 The delivery

The College signpost outside the gate has three arms, marked Kettle Laboratory, Workshops and Deliveries, and all three point at the workshop. On the morning of Monday 21 September 2026 a lorry followed them. It left a crate 4.2 metres long on the gravel by the workshop door, obtained a signature from the porter, who had come across the quad to see what the noise was, and went. The label read 'Deliveries'. There was no consignment note, no sender and no invoice, which is the last of these the Bursar has ever seen and the first he has minded. The College risk-assessment form of 1979, used for everything since, was completed on the Tuesday: Section 4, Hazards, already listed the lawn, the Trebuchet, the open day and Gerald, and the Department has added 'jet'. Under College Regulation 7, which requires that trebuchets point away from the Library, the crate was turned round before it was opened, on the ground that the Regulation does not say trebuchets only.

Inside, in foam, was a Geran-4: a Russian jet-powered one-way attack drone, 3.6 metres long, with a straight wing of 3.05 metres, a turbojet in the tail, a camera in the nose and no warhead. The College does not know who sent it, why, or whether it was meant for somebody else with a workshop, and has written to ask. This paper is what the Department did in the meantime, which was what any department would do with an aircraft and a bench: take it apart, count the pieces, and compare the count with the published record. That record is unusually good, because Ukraine takes real ones apart for a living and publishes the parts list.[3]



Figure 1.1: The crate at the workshop door, Monday 21 September 2026. The porter's signature is on the label; his position on liability is on the back of it. The Department's drawing.

1.2 The questions

The Department set itself five. What is it, and where does it come from (Chapter 2)? What is inside it (Chapter 3)? Who made the inside (Chapter 4)? How many of them are there, and how fast are they made (Chapter 5)? Can they be stopped, and by whom, and at what price (Chapter 6)? Chapter 7 is the wind tunnel, which answered a question nobody had asked. Chapter 8 is the findings. The Bursar's card is Appendix B and is, for once, a bill going the other way.

1.3 Why this Department

The Department of Aeronautical Engineering and Applied Fluid Mechanics owns the Sir Barnes Wallis Subsonic Wind Tunnel, the tall chimney on the College skyline and the only room in Upper Piddlington in which an object can be made to fly at 320 kilometres an hour without leaving. It teaches the MEng in Aeronautical Engineering with Corrugation (KE10), whose founding principle is that an aircraft is a set of parts that have agreed to travel together, and that the agreement can be examined. A one-way attack drone is that principle taken to its conclusion: the parts agree to travel together once. The Department wished to know which parts, from where, and on what terms.

1.4 Method

The drone was disassembled on the workshop bench over four days, in the order the fixings allowed, and each part labelled and catalogued as it came off. The College's count was then set beside the list Ukraine's Defence Intelligence publishes for the Geran-4, which is the authority for every maker and country in this paper; where the College's part carried a legible marking it is noted, and where it did not, HUR's identification stands.[3] The speeds, ranges and dates are from HUR's specification, from The Conversation's account of 25 September 2026, from Radio Free Europe's film of a captured Geran-4 taken apart with Ukrainian specialists, and from Wikipedia's raw text where it cites a source.[1,2,3,6,7] Where they disagree, Chapter 2 says so. The wind-tunnel run is described in Chapter 7 and was performed with the warhead bay empty, the fuel drained and the engine driven by the tunnel, not by itself. Nothing was flown.

College hypothesis. A drone described as Russian will turn out, on the bench, to be Russian in the way the College's tea is Indian: assembled here, grown elsewhere, and paid for by somebody who did not read the label. The Department expects the engine to be Chinese, the electronics to be American, and the body to be the only part that would not fit through customs.

2 THE GERAN FAMILY

2.1 A geranium from Iran

The family began as the Shahed-136, a delta-winged one-way attack drone built by Shahed Aviation Industries in Iran, 3.5 metres long, about 200 kilograms, with a piston engine, a pusher propeller, a top speed of around 185 km/h and a range quoted as 2,500 kilometres, or 1,000 with a heavier warhead.[6] Russia began using them against Ukraine in the autumn of 2022 under the name Geran-2, 'geranium', a name Mrs Partridge has taken personally, the Senior Common Room's geraniums having stood on the same sill since 1962 and never gone anywhere, and leaked Iranian documents later showed that in 2022 Iran sold Russia six thousand of them at \$193,000 a unit, paid partly in gold, with an agreement that Russia would build them itself and a projection that a localised drone would cost \$48,800.[6] The Russian factory is in the Alabuga special economic zone at Yelabuga in Tatarstan, with a target of six thousand by the summer of 2025; the drones it builds were in use by July 2023, and the estimates of what one costs there run from \$30,000 to \$80,000, the higher figure reflecting upgrades and hardening by April 2024.[6,8]

A Geran-2 is slow. That is the whole of the problem it presents to a defender and the whole of the answer: at 185 km/h it can be shot down by a helicopter, a lorry-mounted machine gun or a pilot in a light aircraft with a rifle, and it was; Major MacTavish has asked for the pilot's name, without being asked, and has noted that the pilot was moving, which he regards as an avoidable complication. The Conversation's account puts the interception rate for the propeller types at about 95 per cent.[1] The Bursar, told the price, observed that 95 per cent of \$193,000 is still not nothing, which is the first time he has been right about a weapon.

2.2 The jets

The Geran-3 is the Iranian Shahed-238, the same airframe with a small turbojet in place of the piston engine, shown on Iranian television in September 2023 and found in Ukraine in January 2024; wreckage in June 2025 carried a serial number showing that series production had begun.[7] It is faster, about 330 km/h against the Geran-2's 185, and flies higher, at the cost of range: about 600 kilometres, because the jet drinks the space the fuel used to have.[1] The Geran-4 is a Russian development of it with an improved airframe and a Chinese turbojet of 160 kilograms of thrust, first used against Ukraine in May 2026.[7] The Geran-5, longer, heavier and shaped like a cruise missile, followed in 2026: 6.5 metres, 850 kilograms, a 90-kilogram warhead, up to 600 km/h and 950 kilometres, with an anti-jamming satellite receiver, a Chinese Telefly turbojet and, HUR reports, the ability to be launched from a Su-25 in flight.[1,5,7]

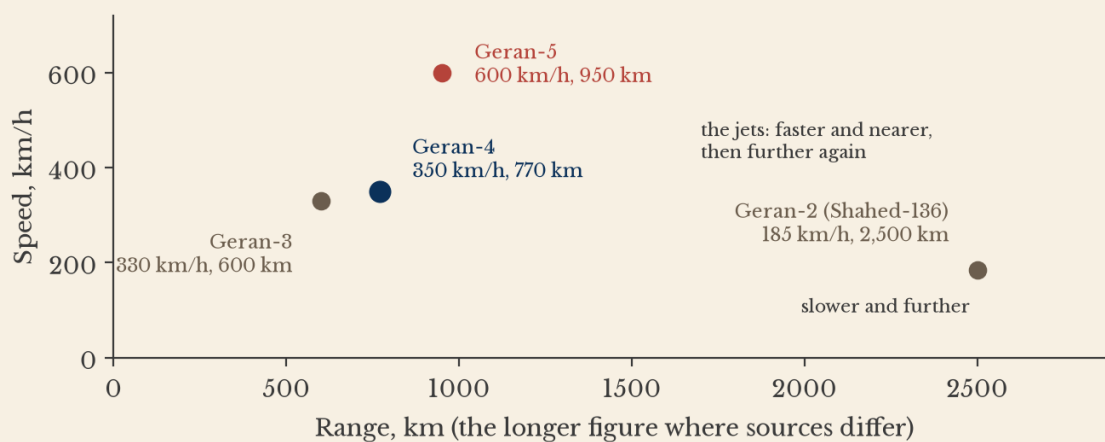


Figure 2.1: The family. Speed against range for the four Gerans, on the sources this paper cites: the propeller drone slow and far, the first jet fast and near, and each jet since further than the last. Data: references 1, 3, 5, 6, 7.

2.3 Three sources, three drones

The Geran-4 has one airframe and several specifications, depending on who is describing it. HUR's page, compiled from wreckage, gives a maximum speed of 350 km/h, a cruise of 320, a range of 770 kilometres, a ceiling of 4 kilometres, a take-off weight of up to 450 kilograms, a 50-kilogram warhead and 2.2 hours of flight.[3] The Conversation gives a top speed of 500 km/h and a range of 850 kilometres.[1] The RFE/RL film, made with Ukrainian specialists around a captured one, gives 450 to 500 km/h 'over Ukrainian territory, sometimes even faster', an altitude of up to 8 kilometres, and a flight from occupied Crimea to Luts'k of more than 700 kilometres.[2] Wikipedia, citing Ukrainian intelligence, gives 500 km/h and 600 to 850 kilometres.[7] Table 2.1 sets them side by side.

Figure	HUR (wreckage)	The Conversation	The RFE/RL film	Wikipedia
Top speed	350 km/h (cruise 320)	500 km/h	450 to 500, sometimes more	500 km/h
Range	770 km	850 km	over 700 km (Crimea to Luts'k)	600 to 850 km
Ceiling	up to 4 km	higher than earlier types	up to 8 km	not given
Warhead	50 kg	not given	not given	50 kg
Weight	up to 450 kg	not given	not given	not given
Engine	Telefly turbojet	jet, Chinese	turbojet, Chinese or assembled in Russia from Chinese parts	Chinese, 160 kgf
First used	not given	later in 2025	not given	May 2026

Table 2.1: One drone, four descriptions. The paper uses HUR's figures for the airframe, because they were measured from wreckage, and reports the others. References 1, 2, 3, 7.

The Department does not think anybody is lying. A drone's top speed depends on its load, its height and whether it is diving at the end, and its range on how much of the tank is fuel and how much is warhead; the film's 8 kilometres and HUR's 4 are likely the same aircraft empty and full. Professor Widdowson-Bligh, shown the three speeds and asked which was right, wrote: 'It is one drone.' Miss Catchpole has filed the four descriptions facing one another, on the ground that the Library is not a wind tunnel either.

3 TAKING IT APART

3.1 The bench

The drone was lifted onto the long bench along the west wall of the workshop, at Gerald's end, on the Tuesday morning, and the College cat moved to the other end without being asked. The fuselage is a tube of composite with a straight wing bolted through it, an engine nacelle in the tail, a nose with a glazed camera window and, between them, a bay where 50 kilograms of warhead would sit and did not. The fixings were ordinary: hex-head screws, two sizes, one of them 10 millimetres, for which the workshop has a socket and knows exactly where it is, at the grating, since 1987. Disassembly took four days. Reassembly has not been attempted, on the advice of the Bursar, who asked what it would be for.

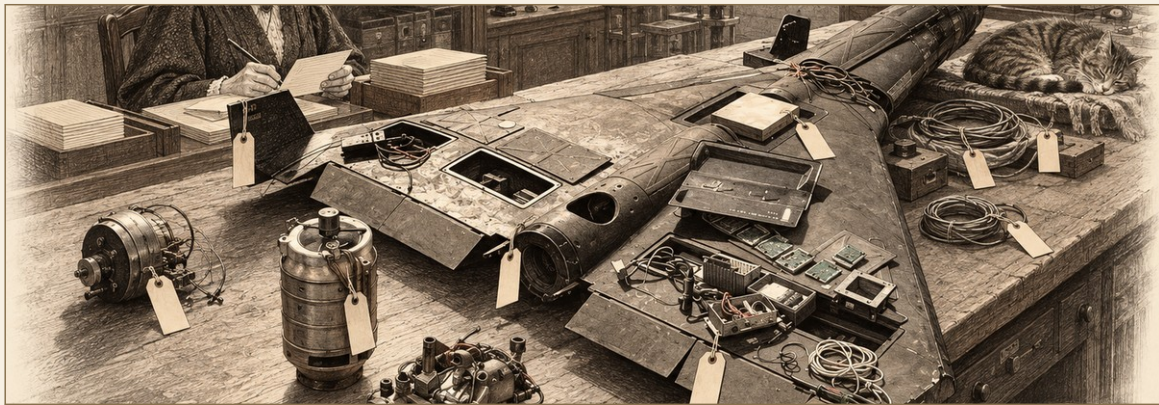


Figure 3.1: The bench on the Thursday. Parts on tie-on labels in the order removed; the engine on its stand at the far end; the stool unoccupied. The Department's drawing.

3.2 The engine

The engine is a small turbojet the size of a fire extinguisher, and it is the reason the Geran-4 exists. HUR identifies it as a Telefly, from Telefly Telecommunications Equipment Co., Limited, of China, the same maker whose JT80 powers the Geran-3 and whose TF-TJ2000A powers the Geran-5; Wikipedia gives its thrust as 160 kilograms.[3,4,5,7] The teardown film's specialists say the engines are Chinese but that they have investigated cases of engines assembled in Russia from Chinese components, which is the sort of distinction the Department of External Procurement was founded to lose sleep over.[2] It is what lets the drone fly at twice the height of a propeller type and at a speed that a helicopter cannot follow, and it is also why the drone is thirsty: the film's specialists put the Geran-4's reach at more than 700 kilometres, HUR at 770, and the Geran-2, on a piston engine and a propeller, went 2,500.[2,3,6]

The College's engine turned over freely, had oil in it and a connector on its control loom that matched nothing on the bench. The one in the shoebox under Gerald's desk fitted. The Department records this without comment, as it records everything about the shoebox.

3.3 The eyes

In the nose is a camera, HUR's list naming it as a Honpho TS130C-01, Chinese, with day, night-vision and infra-red modes; the film's specialists describe ten times optical zoom and up to 32 times digital, enough to read the ground from 8 kilometres up.[2,3] With a relay station in range an operator at a workstation in Bryansk or Crimea can see what the drone sees and steer it, almost in real time.[2] The Conversation adds, from a Russian military commentator, that the newer Geran-5 carries machine vision tied to a digital terrain map so that it can pick its own target; the Geran-4 on the bench had the camera and the map and the Department did not switch either on.[1] The College cat, which had watched the camera come out of the nose from the far end of the bench, was found the next morning sitting in the nose, and has not explained.

3.4 The telephone

Behind the camera is the part the Department had not expected: a telephone. HUR lists a tracker called Borscht V3, with 3G and LTE modems and a Raspberry Pi microcomputer; the film's specialists found two GSM modems and the slots for their SIM cards, and say that they have found SIM cards from Ukraine, Russia, Belarus and 'even some European Union countries' in Geran-4s.[2,3] Once the drone is inside Ukraine an ordinary mobile network carries its position back to the operator, exactly as it would carry a delivery driver's. Beside the tracker is a mesh modem, HUR naming the maker as Xingkey Tech, Chinese, which carries radio and video with a range the film puts at up to 300 kilometres and which can relay: several drones flying together pass the signal along, so that the operator can reach much further than one radio could.[2,3] Mrs Partridge, told that the drone needs four countries' SIM cards to know where it is, said that the urn had never needed to ring anybody and had not moved since 1962, so it was not the same problem.

3.5 The navigation

The Geran-2 was jammed, often, because it steered by satellite and a jammer on the ground is louder than a satellite. The Geran-4 carries an answer: HUR lists an anti-jamming system it calls NASIR, built on a sixteen-element controlled-reception-pattern antenna from Harxon, which listens upward and ignores the ground, an inertial navigation unit called SADRA that keeps the drone on course when the satellites are lost, a GNSS receiver from Unicore of China, an air-data unit and a flight-controller unit.[3] The Geran-3 and -5 carry a Russian-made anti-jamming receiver called Kometa from VNIIR-Progress, which is one of the few electronic assemblies in the family with a Russian maker's name on it.[4,5] The Conversation's point that the new jets are fitted with anti-jamming capabilities is, on the bench, an antenna the size of a dinner plate with a Chinese label.[1] Professor Sir Peregrine Fortescue, told that the antenna's whole purpose is to ignore everything said to it from the ground and attend only to what comes from above, asked whether it constitutes a Fellow.

3.6 The warhead

The bay was empty and the Department is glad of it. HUR's list gives the Geran-4 a 50-kilogram warhead of two types: a thermobaric TBBCH-50M from a Russian applied-chemistry institute, or an incendiary ZBBCH-50 paired with a high-explosive fragmentation OFBCH-2.[3] The Geran-5 carries 90 kilograms.[5] These are the parts that do what the drone is for, and the paper reports them and moves on.

3.7 What is Russian

The specialists in the film, asked what in the drone was actually Russian-made, said mainly the body and the assembly, and that this one had been assembled at Alabuga.[2] HUR's page names the maker of the Geran-4 as Alabuga OEZ PPT JSC, and its warhead as Russian; nearly everything else on its list of 55 components has a foreign maker or none.[3] The College's count agrees. Of the parts on the bench that carried a maker's name, the fuselage, the wing, the fuel tank and the warhead bay were the Russian ones. Mr Stobbs, who drained the tank into a jerrycan on the second day, was asked afterwards where the fuel had gone. He said where the College's water goes, which is the culvert of 1790, and that he would be looking at the grating with more than usual interest.

4 THE BILL OF MATERIALS

4.1 HUR's list

Ukraine's Defence Intelligence keeps a public register called War & Sanctions of the foreign components found in Russian weapons, with the maker's name and the country where the maker has its headquarters. Its Geran-4 page, read on 25 September 2026, lists 55 identified components; its Geran-3 page 45; its Geran-5 page, the newest, 16 so far.[3,4,5] Table 4.1 counts them by country and Figure 4.1 draws it. The Department's expectation, in the hypothesis of Chapter 1, was that the electronics would be American and the engine Chinese. It was right about both and wrong about which there would be more of. Two cautions. The country is where the maker keeps its head office, not where the part was made, which is how Switzerland appears once and the Bursar's tea, made in the Senior Common Room from leaves grown in Assam, would appear nowhere. And the College's own count came to 56, until Miss Catchpole struck out the connector from the shoe-box on the ground that it was not delivered with the drone, merely with the College.

Headquarters country	Geran-3 (45)	Geran-4 (55)	Geran-5 (16)
United States	23	24	9
China	8	15	4
Switzerland	7	1	0
Germany	3	2	1
Japan	1	2	0
Great Britain	2	2	0
Taiwan	0	1	0
Not identified	1	8	2

Table 4.1: Identified components by the maker's headquarters country, HUR's War & Sanctions lists as read on 25 September 2026. References 3, 4, 5.

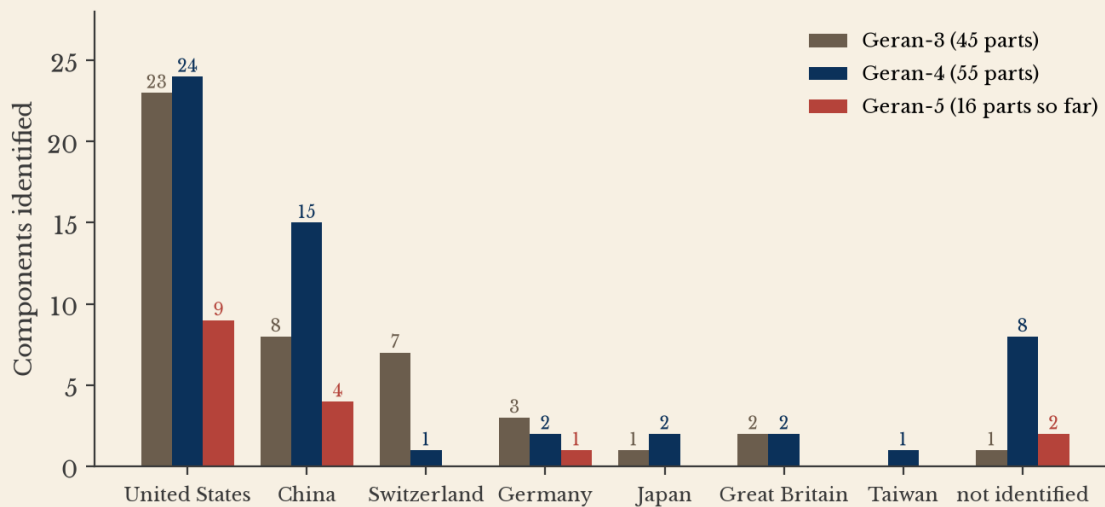


Figure 4.1: The same table drawn. The United States leads every list; China supplies the engine, the camera, the radios and the connectors; Britain supplies two parts to the Geran-4 and both of them are discussed in Section 4.3. Data: references 3, 4, 5.

4.2 The makers

The American parts are the small ones: transceivers, line drivers, voltage regulators, an analogue-to-digital converter, a digital signal processor, memory, diodes and a clock generator. Texas Instruments appears twelve times on the Geran-4's list, thirteen with a National Semiconductor part that is now theirs, and ten times on the Geran-3's, which the Bursar, who has been trying to collect eleven guineas from London since 1941, regards as evidence that Dallas's paperwork is the more efficient; Analog Devices, Micron, ON Semiconductor, Littelfuse, Vishay, CTS and Alpha and Omega make up the rest.[3,4] The Chinese parts are the large ones: the Telefly engine, the Honpho camera, the Xingkay mesh modem, a network switch, the Unicore satellite receiver, a pressure sensor, power converters, capacitors and every connector. Germany contributes an Infineon transistor, Japan a Toshiba phototransistor and a Nichicon capacitor, Taiwan a solid-state relay, Switzerland an STMicroelectronics microcontroller.[3] Table 4.2 gives the named parts.

Part	Maker	Country
Turbojet engine	Telefly Telecommunications Equipment Co.	China
Camera TS130C-01	Honpho	China
Mesh modem	Xingkay Tech	China
Network switch	SCYTON Technology	China
GNSS receiver (two)	Unicore Communications	China
Pressure sensor	Beijing Sensirt Sensor Technology	China
DC/DC converter	MORNSUN Guangzhou	China
USB to UART bridge	Nanjing Qinheng Microelectronics (WCH)	China
Transceiver	Hunan Silicon Internet of Things	China
Capacitors, connectors, terminal block	Hunan Aihua, CapXon, Nanjing Kaida, Ningbo Connfly, KEFA	China
Microcomputer	Raspberry Pi Ltd	Great Britain
Slave to UART converter	Future Technology Devices International	Great Britain
Digital signal processor, transceivers, line drivers, regulators, amplifier (12)	Texas Instruments	United States
Step-down converter	National Semiconductor (Texas Instruments)	United States
ADC, reference source, line driver	Analog Devices	United States
Transceiver	Maxim Integrated (Analog Devices)	United States
Memory chips	Micron; Adesto (Dialog, Renesas)	United States
Schottky diodes, diode, MOSFET	ON Semiconductor; Littelfuse; Vishay; Alpha and Omega	United States
Clock generators (two)	CTS Corporation	United States

Part	Maker	Country
Microcontroller	STMicroelectronics	Switzerland
Transistors (two)	Infineon Technologies	Germany
Phototransistor; capacitor	Toshiba; Nichicon	Japan
Solid-state DC relay	FOTEK Controls	Taiwan
Servo drive, RS-232 driver, Schottky diode, connector, tantalum capacitor, and three more	Not identified	

Table 4.2: The Geran-4's identified components, grouped by maker, from HUR's list of 55 as read on 25 September 2026. Counts in brackets where a maker appears more than once. Reference 3.

4.3 Two British parts

The Department had not expected to find Britain on the list and found it twice. The tracker's computer is a Raspberry Pi, from Raspberry Pi Ltd of Cambridge, a board designed to teach children to program and sold in the tens of millions through ordinary shops; Wikipedia reports one in the Geran-5 as well.[3,7] Beside it is a USB-to-serial converter from Future Technology Devices International of Glasgow, a part found in most things with a cable.[3] Neither company sells to Russia; both sell to everybody, which is how the Conversation's authors reach their conclusion that Russia has built supply chains that buy commercially available parts from many countries and assemble them at home.[1] Miss Catchpole has catalogued the College's Raspberry Pi under 'Apparatus, British, abroad', and has asked whether the Library's own one, which runs the catalogue, should be watched. The Proctor, who keeps the book of items surrendered at the examination door, has asked whether it now goes on the list, and has been told that it does not, but that the ferret is still on it.

4.4 The eight

Eight of HUR's 55 could not be identified: a servo drive, a line driver, a Schottky diode, a connector, a tantalum capacitor and three others whose markings had worn off or were never there.[3] The film's specialists show a chip on the onboard computer with the marking partly worn away and Texas Instruments still legible; the eight are the ones where it was not.[2] The Department notes, for the record, that the College's count of unidentified objects in its own workshop is a shoebox, and that the shoebox is consulted, not catalogued.

5 ALABUGA, AND THE RATE OF PRODUCTION

5.1 The zone

Alabuga is a special economic zone on the edge of Yelabuga in Tatarstan, on the Kama, founded on 21 December 2005 as a joint-stock company to attract factories with tax relief.[8] From 2023 it has been the place where Russia builds its Gerans: the Washington Post reported in August 2023 on the effort to build six thousand with Iran's help, Conflict Armament Research confirmed Russian-built drones in use by July of that year, and HUR names the Geran-4's maker as Alabuga OJSC PPT JSC.[3,6,8] The leaked contract put the price of an imported Shahed at \$193,000, or about \$290,000 for a smaller order of two thousand, and projected \$48,800 for one built at Alabuga with near-full localisation; by April 2024, with upgrades, the estimates were \$30,000 to \$80,000.[6] The Bursar has asked the Department to note that the localised figure is a quarter of the import price, that this is the best example of buying the tooling rather than the product he has seen, and that the College's kettle was made in Sheffield and has cost nothing since 1962 except elements.

5.2 The workforce

Wikipedia's account of the zone, which it flags as needing an update, describes a recruitment programme called Alabuga Start that brought low-skilled workers from 27 countries, many of them young women from Africa and elsewhere, on promises of pay, training and accommodation, to work in the drone factories; and a college, Alabuga Polytech, whose students sign a three-party contract with the college and their parents, under which refusal to work is met with expulsion and a fine of 1.5 to 2 million roubles.[8] The paper reports this as it found it and does not make a joke of it.

5.3 The strike

On 2 April 2024 the factory was struck by a Ukrainian drone that turned out to be a light aircraft, an Aeroprakt A-22 Foxbat, converted to fly itself; Russian media reported a hit on a workers' dormitory.[8] The Department notes that the aircraft that hit the factory making jet drones was a two-seat trainer with a piston engine, a propeller and a range that the Geran-2 would recognise, and that the war's arithmetic does not always run the way the brochure says.

5.4 The rate

On 10 August 2026 Major General Vadym Skibitskyi, deputy head of HUR, told RBC-Ukraine that the planned output of Russia's industry for attack drones of all types in August, Geran-1 to Geran-5, Garpiya and the Gerbera decoys, was 11,000; that in July the Russians had slightly reduced strikes and output while they reconfigured production around the turbojet Geran-4 and Geran-5; and that in one recent attack turbojet drones had already been half the total.[9] The teardown film, citing Ukrainian military intelligence, puts the Geran-4 and Geran-5 alone at around 3,000 a month at Alabuga and other sites.[2] The Conversation reports that Russia is prioritising the two jets to build stocks for an autumn and winter campaign.[1]

Eleven thousand a month is 360 a day, or one every four minutes, day and night. The College produces one paper a day when the illustrator is prompt, and has been asked by the Bursar whether the comparison is useful. It is not. It is recorded.

5.5 External Procurement reads the list

The Department of External Procurement, Regime Restoration and Unintended Consequences was given Table 4.2 and asked how a drone assembled in Tatarstan comes to contain twelve Texas Instruments parts, a Cambridge microcomputer and a Glasgow serial converter under sanctions. It returned the table with one word written on the cover: 'Distributors.' The Conversation's authors say the same at greater length: the component list suggests resilient supply chains that buy commercially available technology from many countries and manufacture the final system at home, and highlights gaps in export-control enforcement.[1] A voltage regulator is not a weapon; it is a voltage regulator until somebody screws it to a warhead, and there are a great many voltage regulators. The Department's view, which it holds without being asked, is that a sanction on a part that is sold by the reel is a sanction on the reel's paperwork, and that Russia has found where the paperwork is thin.

Departmental observation. The drone is not made in Russia so much as finished there. The tube, the wing, the tank, the warhead and the assembly are Russian; the thrust is Chinese; the thinking is American, Swiss and British; the connectors are Chinese and one of them is Gerald's. The word for this is not 'domestic production'. It is 'kit'.

6 INTERCEPTING IT

6.1 Sixty per cent

On 14 September 2026 Colonel Yuriy Ihnat of the Ukrainian Air Force told the Financial Times that Ukraine was intercepting only about 60 per cent of the new Geran-5s, against 95 per cent for the other drone types, and that the air force had been forced into the 'very intensive use' of fighter jets since August, with pilots shooting the drones down directly.[1] Figure 6.1 draws the two numbers. The Geran-4 sits between the propeller types and the Geran-5 on every measure in Table 2.1 and the sources do not give it a rate of its own; the Department has not invented one.

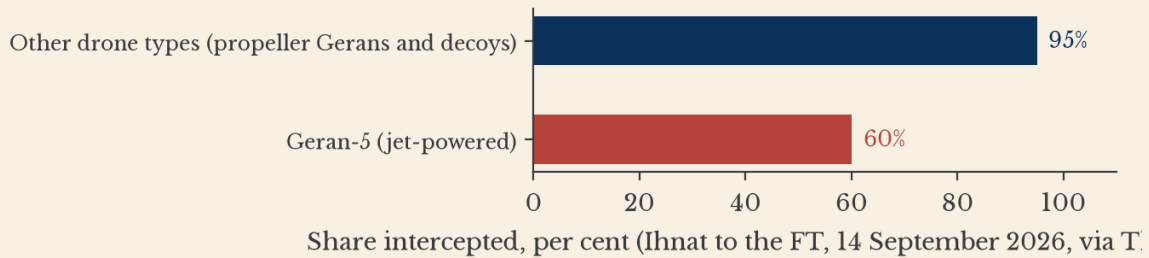


Figure 6.1: What gets through. The interception rate the Ukrainian Air Force gave the Financial Times on 14 September 2026 for the Geran-5 and for the other drone types, as reported by The Conversation. Reference 1.

The reason is in the numbers of Chapter 2. A thing doing 185 km/h at low level can be shot with a machine gun from a pickup; a thing doing 500 or 600 km/h at 4 or 6 kilometres cannot, and needs either a fighter or a missile with a rocket in it. The Conversation reports that Ukraine's stock of Patriot missiles, ground and air launched, is running low, that these are the only truly effective means against the Geran-5, and that General Skibitskyi said in August that Ukraine now needs interceptors 'with the appropriate speed', or short-range air defence, to match the jets.[1,9] On 19 September the SBU released film of a new interceptor drone of its own bringing down a Geran-5, which it called the first footage of a jet drone destroyed that way.[7]

6.2 The price of shooting

Wikipedia's summary of the economics, which the Department repeats because the Bursar asked it to, is that a Shahed-series drone costs somewhere around \$20,000 to \$80,000 depending on who builds it and where, while an interceptor missile costs between \$400,000 and \$1.2 million.[6] Figure 6.2 draws the ranges. The arithmetic is the drone's whole argument: it does not need to arrive, it needs to be shot at. The Bursar, who has spent thirty years explaining to the Fellows that the cost of stopping a thing must be compared with the cost of the thing, has found a case where everybody agrees with him and has not enjoyed it.

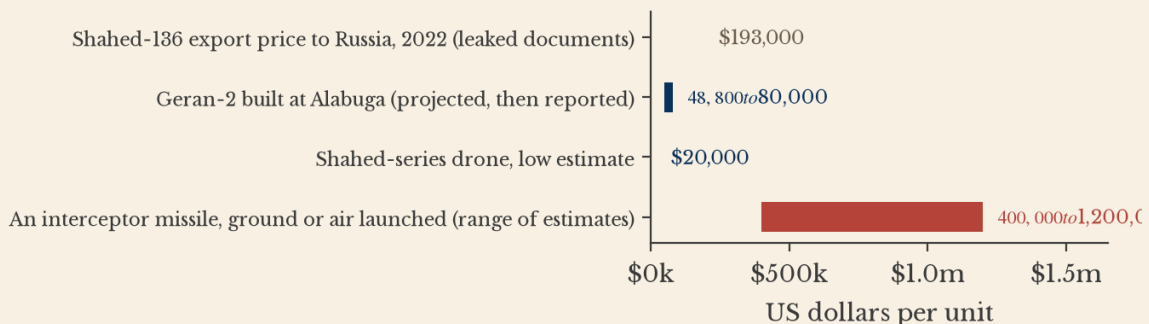


Figure 6.2: A drone against what shoots it down. Unit prices as the sources give them: the 2022 import price, the projected and reported Alabuga costs, the low estimate for the type, and the range quoted for an interceptor missile. Reference 6.

6.3 The College's contribution

The Department circulated a note asking what the College could put up against a Geran-4, on the strict understanding that nothing would be put up against anything. The replies are in Table 6.1 and are fiction. The Trebuchet Research Group offered the Trebuchet, which has a range of about 150 metres, a projectile speed the Group declined to state, and, under the Agreement of the Water Meadow, permanent control of a defence area it has not left; it noted that it has never missed a target that stayed still. Major MacTavish, without being asked, observed that a thing that flies 770 kilometres to reach you has done the moving for you, that the rifle, the brew and not moving are therefore all still available, and that he would be on the path. Mrs Partridge offered the urn, on the ground that it has infinite life and the drone has two hours and twelve minutes. Mr Stobbs asked that whatever was chosen be chosen off the lawn.

Candidate	Reach	Speed	Cost each	Availability
Patriot interceptor	tens of km	several times sound	\$400,000 to \$1.2 million	running low[1,6]
A fighter and its pilot	the country	faster than the drone	not per shot	in very intensive use[1]
The SBU's interceptor drone	not published	enough, on 19 September	not published	new[7]
The Trebuchet	about 150 m	not stated	the Group's budget, questioned	permanent, has not moved
The Major's rifle	to the lawn wall	sufficient	a brew	not moving
The urn	the Senior Common Room	nil	an element, every twenty years	infinite

Table 6.1: Interceptors, real and College. The first three rows are the sources'; the last three are fiction, and the Department has asked that nobody try them.

Departmental finding. The Geran-4 is not a better drone than the Geran-2. It is a faster one, and the difference between 185 and 350 kilometres an hour is the difference between a machine gun and a missile that costs twenty times the target. The engine is the argument, the engine is Chinese, and the argument is being made three thousand times a month.

7 THE WIND TUNNEL

7.1 The run

On the Friday the airframe, reassembled without engine, fuel or electronics and with the bay ballasted to HUR's weight, was mounted in the Sir Barnes Wallis Subsonic Wind Tunnel and run at the cruise speed HUR gives, 320 kilometres an hour, which is 89 metres a second and about Mach 0.26 at the Tunnel's temperature (Appendix A). The Tunnel, which was built for airships and has since tested a kettle, a biscuit and the Vice-Chancellor's gown, held it without complaint, having been tapped three times with the silver spanner by the Vice-Chancellor before the run, which is not in the operating manual and is in the College's. The Department measured lift and drag at four angles, found the straight wing to do what straight wings do, and found nothing that the published range and speed had not already told it. The finding of the run is that the Geran-4 is subsonic. This was known. It is now known at the College's expense, which is the Department's usual standard of proof.

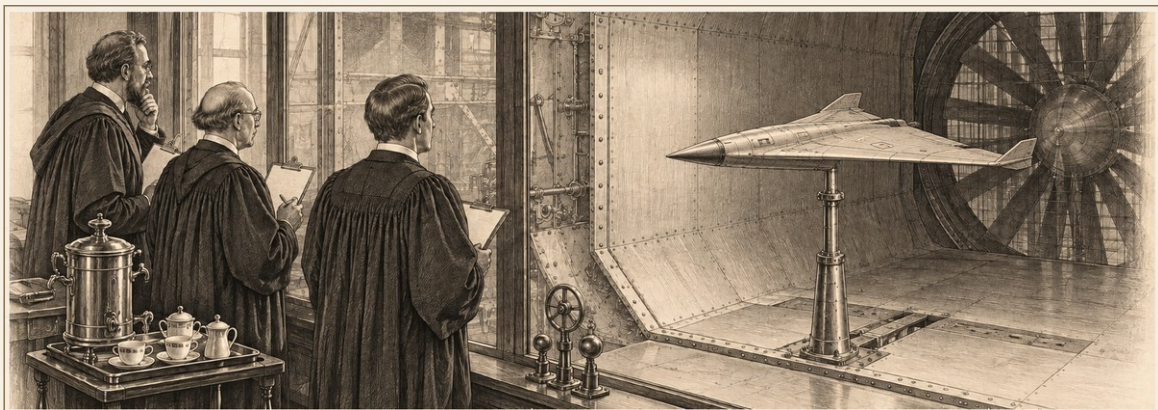


Figure 7.1: The airframe in the Sir Barnes Wallis Subsonic Wind Tunnel, Friday 25 September 2026, with the Department in attendance and the urn on its trolley. The Department's drawing.

7.2 What it told us

Two things, and neither about the drone. The first is that the Conversation's description of the Geran-5, a cylindrical fuselage and straight wings closer to a cruise missile than a drone, applies in smaller measure to the Geran-4, which is a tube with a wing through it and a jet behind: the Department could see, at 320 kilometres an hour, why the designers stopped pretending it was an aeroplane.[1] The second is that the Tunnel's own chimney is visible from the water meadow, and that the Trebuchet Research Group has asked whether, under the Agreement of the Water Meadow, it constitutes a target. Mr Stobbs has said that it constitutes a chimney.

8 CONCLUSIONS

8.1 The questions answered

What is it: the third jet in a family that began as an Iranian propeller drone, Russian-built at Alabuga since 2023, in use since May 2026, 3.6 metres long, 770 kilometres of range, 320 kilometres an hour at cruise and a 50-kilogram warhead, on the figures measured from wreckage.[3,7] What is inside it: a Chinese turbojet, a Chinese camera, a Chinese mesh modem, a British microcomputer with mobile-telephone modems and SIM cards from four countries, an anti-jamming satellite antenna, and a great many small American parts.[2,3] Who made the inside: on HUR's list of 55, the United States 24, China 15, Britain, Germany and Japan two each, Taiwan and Switzerland one each, eight unknown; Russia made the body, the tank, the warhead and the assembly.[3] How many: eleven thousand attack drones of all types planned for August 2026, of which the jets are the priority and, on one account, three thousand a month.[2,9] Can they be stopped: the propeller types 95 times in a hundred, the Geran-5 60, by fighters and by missiles that cost twenty times the drone and are running out.[1,6]

8.2 What the Department makes of it

The drone is a kit. The parts are ordinary and are sold by the reel to anybody with a company name, and the countries on the list are not the countries that sent them, but the countries where the makers keep their headquarters; the sanctions gap, as the Department of External Procurement said in one word, is the distributor. The engine is the only part that changed the war, and it is the only large part with a single maker's name on it, and that name is Chinese. The rest of the drone is a telephone with a bomb in the boot.

Principal finding. A Russian drone described as domestically produced contains more American parts than Chinese ones, two British ones, and one connector that fitted only because Gerald had it. The part that matters is the engine, the engine is Chinese, and the difference it makes is the difference between a rifle and a missile. The College has counted the parts, filed the Raspberry Pi under 'British, abroad', and asked for the crate to be collected. Nobody has come.

8.3 Disposition

The airframe remains on the bench at Gerald's end, catalogued, labelled and unpowered. The engine is on its stand with Gerald's connector in it, which the Department has decided not to remove in case the shoebox wants it back. The Bursar's card is Appendix B and proposes to invoice each country for its parts, pro rata, at eleven guineas, which is the only sum the College has ever charged anybody for anything and which nobody has yet paid. Mr Stobbs has asked that the drone not be moved to the lawn, the meadow or the ha-ha, and it has not been.

REFERENCES

- [1] M. Miron and R. Thornton, 'Russia's new jet-powered drones mark latest evolution in air war above Ukraine', The Conversation, 25 September 2026: Ihnat to the FT of 14 September (60 and 95 per cent, fighters); the Geran-3, -4 and -5 figures; Knutov on machine vision; the component countries; Patriot stocks; Skibitskyi's interceptors. theconversation.com
- [2] Radio Free Europe/Radio Liberty, 'What You Need To Know About Russia's New Geran-4 Drone', film, 25 September 2026: a captured Geran-4 taken apart with Ukrainian drone specialists; transcript supplied by the reader: the engine, altitude and speed; the camera's zoom; the GSM modems and SIM cards; the mesh modem's range and relaying; the Texas Instruments marking; Alabuga; 'around 3,000 Geran-4 and Geran-5 drones a month'. youtube.com
- [3] Defence Intelligence of Ukraine, War & Sanctions, 'Geran-4 UAV': the specification and the list of 55 identified components by maker and headquarters country, read 25 September 2026. war-sanctions.gur.gov.ua
- [4] Defence Intelligence of Ukraine, War & Sanctions, 'Geran-3 UAV': 45 components; the Telefly JT80; the Ko-meta receiver; the Bosch fuel pump. war-sanctions.gur.gov.ua
- [5] Defence Intelligence of Ukraine, War & Sanctions, 'Geran-5 UAV': the specification (6.5 m, 850 kg, 90 kg, 950 km, up to 6,000 m); the Telefly TF-TJ2000A; the Borscht tracker; 16 components so far. war-sanctions.gur.gov.ua
- [6] Wikipedia, 'HESA Shahed 136', raw text read 25 September 2026: 185 km/h, 2,500 km, the 2022 sale of 6,000 at \$193,000 and \$290,000, the projected \$48,800, \$30,000 to \$80,000 by 2024, Conflict Armament Research's July 2023 finding, the interceptor cost range, as cited there. en.wikipedia.org
- [7] Wikipedia, 'Shahed drones', the Shahed-238 (Geran-3), Geran-4 and Geran-5 sections, raw text read 25 September 2026: the September 2023 unveiling, January 2024 in Ukraine, June 2025 serial numbers; the Geran-4's 160 kgf Chinese engine and May 2026 debut; the Geran-5's Su-25 launch and Raspberry Pi; the SBU interceptor footage of 19 September 2026. en.wikipedia.org
- [8] Wikipedia, 'Alabuga Special Economic Zone', raw text read 25 September 2026: founded 21 December 2005; the Washington Post of 17 August 2023 on the 6,000-drone effort; Alabuga Start and Alabuga Polytech; the strike of 2 April 2024 by an Aeroprakt A-22, as cited there. en.wikipedia.org
- [9] 'Russia plans to produce 11,000 Geran, Gerbera and other attack drones in August', Ukrainska Pravda, 10 August 2026, reporting Major General Vadym Skibitskyi's interview with RBC-Ukraine: 11,000; the July reconfiguration; turbojet drones half of one attack; interceptors 'with a matching speed'. pravda.com.ua
- [10] Y. Ihnat, interview, Financial Times, 14 September 2026, as quoted in reference 1. The Department did not read the FT; the College does not subscribe, and the Bursar has explained why.

APPENDIX A - SAMPLE CALCULATIONS

A.1 The wind tunnel

320 km/h = $320,000 / 3,600 = 88.9$ m/s. Speed of sound at 15 C = 340 m/s. Mach number = $88.9 / 340 = 0.26$. At the top speed HUR gives, 350 km/h = 97.2 m/s, Mach 0.29. At the film's 500 km/h, 138.9 m/s, Mach 0.41. Subsonic on every source. The Tunnel is rated to Mach 0.3 and was run at 0.26.

A.2 Time and distance

HUR: 770 km at 320 km/h cruise = 2.41 h, against a stated flight time of 2.2 h; the difference is climb, reserve and the fact that a one-way drone keeps no reserve. Crimea to Luts'k, the film's flight: 'more than 700 km' at 450 to 500 km/h = 1.4 to 1.6 h.

A.3 The bill of materials

Geran-4, HUR: 55 parts. United States 24 = 43.6 per cent; China 15 = 27.3; not identified 8 = 14.5; Germany, Japan and Great Britain 2 each = 3.6 each; Taiwan and Switzerland 1 each = 1.8 each. Texas Instruments 12, 13 with National Semiconductor = 23.6 per cent of the list from one maker. Identified parts with a Russian maker's name on HUR's Geran-4 page: the warhead. Geran-3: 45 parts, United States 23 = 51.1 per cent. Geran-5: 16 so far, United States 9 = 56 per cent.

A.4 The rate

11,000 a month / 31 days = 355 a day = 14.8 an hour = one every 4.05 minutes. 3,000 jets a month = 97 a day = one every 15 minutes. College papers: about one a day = one every 1,440 minutes. Ratio, drones to papers: 355 to 1. The Bursar has asked that this not be shown to the Governing Body.

A.5 The price of shooting

Interceptor \$400,000 to \$1,200,000 against a drone at \$20,000 to \$80,000: ratio 5 to 60. At the 2022 import price of \$193,000 the ratio is 2 to 6, which is the last time it was under ten. Eleven guineas is £11.55 and does not appear on either side.

APPENDIX B - THE BURSAR'S CARD

The Bursar has asked that the following be entered as a proposed invoice, pro rata by count of parts on HUR's list, at the College's standard charge, and has initialled each line. It is fiction and has not been sent.

Addressee	Parts	Share	Charge	The Bursar's note
The United States of America	24	43.6%	£5.04	mostly one company; invoice Dallas
The People's Republic of China	15	27.3%	£3.15	the engine; charge extra for the noise
The Federal Republic of Germany	2	3.6%	£0.42	two transistors; reasonable
Japan	2	3.6%	£0.42	a capacitor and a phototransistor; also reasonable
Great Britain	2	3.6%	£0.42	pay ourselves; carry forward
Taiwan	1	1.8%	£0.21	a relay
Switzerland	1	1.8%	£0.21	a microcontroller; will be paid promptly
Not identified	8	14.5%	£1.68	to the shoebox; it will know
Total	55	100%	£11.55	eleven guineas; not a precedent

Table B.1: The Bursar's card. Eleven guineas divided among the countries on HUR's list by share of the 55 parts. The Bursar notes that the sum owed to the College by H.M. Government for tubes since 1941 is the same, and that he finds the coincidence suggestive. Professor Widdowson-Bligh does not.

APPENDIX C - DEPARTMENTAL NOTE

The Department of Aeronautical Engineering and Applied Fluid Mechanics teaches the MEng in Aeronautical Engineering with Corrugation (KE10). From Michaelmas 2026 the third-year module on propulsion will include a bench exercise with the Geran-4's engine, on its stand, not started, with the question: 'Here is a turbojet the size of a fire extinguisher, made in one country, screwed to a tube made in a second, steered by a computer made in a third for children, and paid for by nobody who will admit it. Identify which part changed the war. Show your working. Do not remove the connector.'

The Department records that the crate is still by the workshop door, that the signpost still points at it, and that the porter's position on liability has been adopted by the Governing Body as College policy.

Persevera Etelred