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The V1 (Flying Bomb) attack on London (1944–1945); the applied geography of early cruise missile accuracy

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ABSTRACT

In a 291 day period in the latter stages of WW2 (1944–45) 10,386 V1 cruise missiles were launched against the UK from ground ramps in France and Holland, and from modified He-111 bombers flying off the south and east coasts of England. The attack mainly targeted London and despite a highly effective British campaign of in-flight interception, 2420 V1 missiles (23% of those launched) made explosive impact on the London target area resulting in significant loss of life and massive damage to London's housing stock. Using data from *The National Register* of 1939 we reconstruct the target geography of London and utilising a vast body of archival data from The National Archives we also reconstruct the V1 impact geography; in doing so we evaluate the accuracy of the V1 attack. Most missiles struck near the centre of the London target in areas of high population density; 40% of the missiles fell on the County of London forming the inner core of the London Civil Defence Region containing 38% of its 1944 population in only 16% of its area. The overall Mean Point of Impact is within 3.5 km of the centroid of the County of London. V1 impact density showed similar Clarke-like distance-decay relations to population density in relation to an assumed Central London aiming point. We also determine the accuracy metrics for the V1 attack. Our results verify the idea that high-resolution accuracy is moot when missile systems with relatively low accuracy are launched against large area targets, such as large cities. Although compared to modern missile systems the V1 was "inaccurate", we find that the German cruise missile system fulfilled the operational accuracy requirements to achieve its terror and urban damage objectives.

1. Introduction

1.1. The German missile attacks on London (1944–1945)

The German missile attacks on London during the latter stages of WW2 (1944–45) were the first such attacks in modern war. The missiles deployed against London were the V1 cruise missile (also known as the Flying Bomb and colloquially as the "Doodlebug"), developed by the German Air Force, and the V2 ballistic missile (also known as the A4 rocket or the Long Range Rocket Projectile) developed by the German Army (Barber, 2017; Hölsken, 1994; Irving, 1964; Pocock, 1967; Young, 1978; Zaloga, 2005). The German missile attacks took place in a 291-day period between June 12, 1944 and March 29, 1945 (Campbell, 2013; Collier, 1957, 1964; Longmate, 1981; USSBS, 1947a). In the V1 attack (June 12, 1944 to March 29, 1945), 10,386 V1 cruise missiles were launched against the UK from ramps in France and Holland, and from modified He-111 bombers flying off the south and east coasts of England (Evans and Delaney, In Review; Smith, 2006). 7573 V1 missiles (73% of those launched) were considered non-abortive and thus presented a net threat to British defences; of these, 3986 missiles (38% of those launched) were destroyed in flight by British countermeasures (Hill, 1948, pp. 5585–5617; Evans and Delaney, In Review) while 2420 V1 cruise missiles made explosive impact on the London target area (23% of those launched; Table 1). By comparison, in the V2 attack (September 8, 1944 to March 27, 1945) 1403 rockets were launched into ballistic trajectory against UK; 1054 impacted British soil of which 517 made explosive impact within the London target (39% of those launched; Table 1).

Both missiles were autonomous. They were conceptualised as terror weapons for use against civilian populations in urban areas and were designed to damage/destroy the built environment on impact; their impact occurred essentially without warning to the population at risk

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Table 1
Comparative summary data on V1 cruise and V2 ballistic missiles (reproduced from Evans and Delaney (In Review)).

	V1	V2
Range (km)	255	352
Launch Weight (kg)	2180	12,700
Fuel Weight (kg)	702	8410
Warhead Weight (kg)	848	735
Average speed (km/hr)	555	3600
Number of missiles constructed by Germany	32,750	6550
Total number of missiles launched by Germany	22,480	3170
Number of missiles launched against NW Europe	12,094	1767
Number of missiles launched against UK	10,386	1403
Number of missiles striking London Civil Defence Region	2420	517

and high-explosive warheads (Table 1) were fused for maximum blast effect and thus maximum surface damage (Hellmold, 1999; p. 219). In this first distal war, German missile impacts accounted for 26% of London's fatalities due to aerial bombardment during WW2 and resulted in massive damage to London's housing stock (data in Titmuss, 1951; Kohan, 1952). The attacks took place despite an aggressive Allied bombing campaign beginning in 1943 designed to interrupt engineering development, suppress production and supply, and destroy launching sites and supply depots associated with the V1 and V2 missile systems across a broad expanse of France, Holland and Germany (Overy, 2013; USSBS, 1947b).

1.2. Conceptual scope and objectives

Here we examine the V1 cruise missile attack and explore both the target and impact geography of the attack on London. In comparing the two geographies we investigate the accuracy of the V1 attack through mapping the interface of two spatial patterns generated by the interaction of an attractor (missile target) and a driver (missile impacts). Missile impacts mark the end point of a flight trajectory; thus the impact geography is filtered by such factors as launch success, flight reliability, and guidance accuracy (e.g., Mackenzie, 1990). Importantly, missile launch may be suppressed by pre-emptive action while missile trajectory can be interrupted by in-flight interception or system malfunction. These actions modify missile impact geography; as described in detail by Hill (1948, pp. 5585–5617) these were key determinants on the distribution of impacts of the V1 (launch suppression and flight interception).

Contemporary government documents concerning the V1 offensive (e.g., TNA AIR 19/417), and subsequent historical accounts of the attack (e.g., USSBS, 1947c, Collier, 1957, pp. 396, 432–433; 1964, p. 139–142; Ordway & Sharpe, 1979, pp. 244–245; Howard, 1990. p. 180) frequently refer to the “inaccuracy” of the German cruise missile system; despite this assertion, the damage to the built environment of London by V1 impacts was considerable and the loss of life substantial. In this paper, we examine this paradox through an analysis of the target geography of London and the impact geography of the V1 attack on the British Capital. Our objectives are to (i) outline the geographic and demographic characteristics of the London urban target in 1944–45, (ii) determine the impact geography of the cruise missile attack, (iii) estimate the population at risk (and its density) in the London target area, iv) explore the interface between the impact geography of the V1 missile attack in relation to target characteristics (urban geometry and population), v) examine the accuracy of the attacks and outline the implications for the geography of missile warfare. This paper forms part of a larger work investigating the response of physical and human elements of the urban environment to conventional missile attack, i.e., the geography of missile warfare conditioned by high-explosive impact.

1.3. Data sources and methods

Remarkably, no official history (based on original documents and data) of the V1 attacks, documenting its scale, chronology, geography, and effects has ever been prepared. However, the occurrence, impact and effects of the missile attacks on London were meticulously recorded by different British military and local government organisations, documented in the field, and analysed in depth by British government investigators in documents now held at The National Archives (TNA) at Kew. This large body of declassified material represents a unique documentation and analysis of the response of a densely populated urban landscape to conventional missile attack and provides the basis for an applied geography analysis. However, these records remain relatively inaccessible in scattered locations within the collections of The National Archives. For this work, we located, reviewed, and extracted a large volume of this fragmentary data from documents at The National Archives. In addition we extracted population and geographic data from *The National Register* of 1939 (HMSO, 1944). Geospatial data from these sources was synthesised, georeferenced, and analysed using ArcGIS software.

2. The London target I - geometry

In the V1 offensive against the United Kingdom, Germany almost exclusively targeted London (Collier, 1957, 1964; Hölsken, 1994). In TNA documents, missile incident/impact data for the offensive is reported for the affected English counties as they were defined in 1944–45, and the wartime London Civil Defence Region (Civil Defence Region 5; O'Brien, 1955) which we abbreviate as LCDR (Fig. 3). London is therefore defined here in terms of the LCDR as mapped in Fig. 1.

The area of the LCDR thus defined (Fig. 1; Supplementary S1), calculated from the area of the 95 administrative units given in *The National Register* of 1939 (Table I in HMSO, 1944), was 1869 km^2, equivalent to a circle with a radius of 24.4 km. Using the same data, the County of London, forming the inner core of LCDR, had an area of 303 km^2 (16% of the area of LCDR), equivalent to a circle with radius of 9.8 km. This extensive urban footprint of the British capital and its inner core represented the primary target of the German missile offensive (Fig. 1).

With reference to a Central London aiming point for the V1 offensive, two aiming points are given in published sources and archival documents, i.e., Tower Bridge and Charing Cross Station (see discussion in Supplementary S2). Published sources (e.g., Howard, 1990; Hölsken, 1994, p. 198; Jones, 1978, p. 422; Werrell, 1985, p. 47; Woolven, 2002; Young, 1978, p. 82, p. 56) give Tower Bridge as the aiming point whereas a number of archival documents assume the aiming point for the V1 attack was Charing Cross Station “or thereabouts” (e.g., TNA AIR 20/4261; TNA CAB 80/86; TNA WO 291/305). These aiming points are within a circle of 1.7 km radius in Central London. We have been unable to find confirmation or detailed definition of missile aiming points in primary official sources in The National Archives although, as discussed below, there is archival evidence suggesting that in the final phases of the main V1 offensive several aiming points in Central London were used by the German missile batteries, rather than one (see for example, TNA AVIA 11/60 and discussion in Supplementary S3).

Thus, for the purposes of this paper we assume a nominal primary aiming point for all V1 missiles launched against the London target to be Tower Bridge at 51.505°N/0.075°W (Fig. 1). The distance from the nominal aiming point to the centroid of the County of London (51.489732°N/0.079676°W) is 2.15 km (Fig. 1).

[1] This alphanumeric code is the reference number for the document in The National Archives (TNA) online catalogue at http://discovery.nationalarchives.gov.uk/.