

# **Little Boys and Blue Skies: Drones through Post-Atomic Eyes**

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‘Hiroshima, an event that is not over: there is a continuity between the atomic bombing and the current situation of war.’

Rosalyn Deutsche, *Hiroshima after Iraq*

Virtually as soon as the dream of human flight was realized, another replaced it: the tantalizing prospect of removing those magnificent men from their flying machines. Most of the early attempts were paper aeroplanes that never flew far from the drawing board; those few that did were largely unsuccessful. But the dream remained alive, and it was given a new lease of life by the deadliest weapon in human history: the atomic bomb. For all the glaring differences between atomic bombs and the Hellfire missiles fired from Predators and Reapers – in scales of investment; in range of delivery systems; in targets and blast radii; and in the time and space horizons of their explosive and toxic effects – nuclear weapons and drones have been entangled in myriad ways. Their development and deployment have involved geopolitical and geo-legal manoeuvres, sparked major oppositional campaigns by activist groups, and had major impacts on popular culture. But, as I seek to show in the pages that follow, the most persistent connection between them has been an unwavering focus on the vulnerability of American lives and the disposability of others’.

## **Escape from Hiroshima**

Before flying the *Enola Gay* across the blue skies above Hiroshima in the early morning of 6 August 1945 Lt Col Paul Tibbets and his crew had repeatedly practiced bombing runs from their base at Wendover Army Air Field in Utah. With other selected B-29 crews they had dropped huge, orange-painted dummy bombs (‘pumpkins’) modelled on the shape and size of what they would eventually

discover to be the plutonium bomb – ‘Fat Man’, the bomb that would destroy Nagasaki, not the ‘Little Boy’ uranium bomb that devastated Hiroshima <sup>1</sup> – on vast target circles outlined on the desert floor of the nearby Bonneville Salt Flats and the Salton Sea 500 miles away in California. Each week since September the crews had made as many as 30 visual drops and three or four radar-guided drops (the initial meeting of the Targeting Committee had considered visual bombing essential), and Tibbets drove his men hard. Although he was a veteran of US bombing missions over Europe and North Africa, his new mission demanded exceptional skills. In the European theatre it was expected that most bombs would land within 1000 feet of the target (the ‘Circular Error Probable’), but Tibbets and his men were expected to deliver their top secret payload from high altitude (30,000 feet) and yet achieve a CEP of only 200 feet. Tibbets was in command of a stripped-down B-29 Superfortress, modified to allow for an atomic bomb that weighed 10,000 lbs. In June his 50<sup>th</sup> Composite (‘self-contained’) Group deployed to its operational base on Tinian in the Mariana Islands, and the practices continued. The bombardiers started to drop ‘pumpkins’ (conventionally armed but now replicating the shapes of both Little Boy and Fat Man) from flights of three B-29s outside the potential target cities, so that when the day dawned Special Bombing Mission 13 – the flight of the *Enola Gay* and its two accompanying aircraft <sup>2</sup> – would be unlikely to be intercepted when its planes appeared overhead. <sup>3</sup>

The practice runs over the proving grounds in the US and over Japan were

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<sup>1</sup> Little Boy was the progeny of the Manhattan Project’s unsuccessful development of the Thin Man nuclear bomb (which like Fat Man relied on plutonium rather than uranium for fission); Thin Man had been abandoned in July 1944.

<sup>2</sup> The second B-29 dropped an instrumentation package by parachute, designed to measure the intensity of the blast and the radiation yield, while the third was equipped with high-speed cameras to provide a visual record. This followed the protocol established for the first detonation of an atomic bomb three weeks earlier – ‘Trinity’, a test carried out by a tower-blast in New Mexico on 16 July – when two instrumentation/observation B-29s circled the blast: Darrell Dvorak, ‘The first atomic bomb mission’, *Air Power History* 60 (45) (2013) 4-17.

<sup>3</sup> Japanese radar detected incoming aircraft at 0715 and a yellow alert was issued, but the warning was rescinded shortly afterwards when radar operators determined that the flight was at most three enemy aircraft.

about more than accuracy and deception. They were also designed to enable pilots to execute a diving quarter-roll at high speed as soon as the bomb had been released. It was this, as much as the ability to minimize the CEP, which was the ‘precision flying’ that preoccupied Tibbets and his crews (Figure 1). In September, J. Robert Oppenheimer, the director of the Manhattan Project, had told Tibbets that the most dangerous part of his mission – for the aircrew, at least – would be escaping the shock wave from the air blast. The only solution – and there were no guarantees – was to reverse the flight path abruptly and to put as much distance as possible between the blast and the aircraft.<sup>4</sup> As Tibbets recalled:

‘I told him that when we had dropped bombs in Europe and North Africa, we’d flown straight ahead after dropping them – which is also the trajectory of the bomb. But what should we do this time? He said, “You can’t fly straight ahead because you’d be right over the top when it blows up and nobody would ever know you were there.” He said I had to turn tangent to the expanding shockwave. I said, “Well, I’ve had some trigonometry, some physics. What is tangency in this case?” He said it was [155] degrees in either direction. “Turn [155] degrees as fast as you can and you’ll be able to put yourself the greatest distance from where the bomb exploded.”

‘I had dropped enough practice bombs to realise that the charges would blow around 1,500 feet in the air, so I would have 40 to 42 seconds [between bomb drop and blast] to turn [155] degrees. I went back to Wendover as quick as I could and took the airplane up. I got myself to 25,000 feet, and I practised turning, steeper, steeper, steeper and I got it where I could pull it round in 40 seconds. The tail was shaking

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<sup>4</sup> Richard Campbell, *The Silverplate bombers* (Jefferson NC: McFarland, 2005); John T. Correll, ‘Atomic mission’, *Air Force Magazine* 93 (10) (2010) 73-76; Paul Ham, *Hiroshima Nagasaki* (New York: Doubleday, 2011) pp. 283-98; Andrew Rotter, *Hiroshima: the world’s bomb* (Oxford: Oxford University Press, 2008) pp. 187-193. This is also why the bomb had to be dropped from such a high altitude.

dramatically and I was afraid of it breaking off, but I didn't quit. That was my goal. And I practised and practised until, without even thinking about it, I could do it in between 40 and 42, all the time.' <sup>5</sup>

At 0815 the bomb-bay doors of the *Enola Gay* opened, and 40 seconds later Little Boy exploded 1,900 feet above Shima Hospital in the centre of Hiroshima. By the time the *Enola Gay* was hit by the first shock wave with a force of 2½ G the aircraft was ten miles away.

### **Atomic clouds and drones**

One of the immediate American responses to the attacks on Hiroshima and Nagasaki was a belief that the atomic bomb heralded the chilly dawn of what journalist Hanson Baldwin called 'devastating "push-button" battles'. <sup>6</sup> In the dog days of the war General Henry 'Hap' Arnold had been convinced that remote controlled, television-assisted aircraft would soon 'fly over enemy territory and look through the leaves of trees and see whether they're moving their equipment.' 'I see a manless air force', Arnold told his chief scientific advisor, and on the day that Japan surrendered he predicted that 'the next war may be fought by airplanes with no men in them at all.' <sup>7</sup> At a press conference a few days later he conjured up the prospect of what he called a 'Buck Rogers conception of war' that would include

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<sup>5</sup> 'Studs Terkel [interviewing Paul Tibbets], 'One hell of a big bang', *Guardian*, 6 August 2002. In fact, what Tibbets had to do was turn until the line from the detonation to the aircraft was a tangent to the turn radius. There is some dispute over the precise escape angle, which has been variously quoted as 150, 155 and 159 degrees: see the preface to Paul Nahin, *Chases and escapes: the mathematics of pursuit and evasion* (Princeton: Princeton University Press, second edition, 2012) pp. xviii - xxvi.

<sup>6</sup> Hanson W. Baldwin, 'The "Drone": portent of a push-button war', *New York Times*, 25 August 1946.

<sup>7</sup> Michael Sherry, *The Rise of American Air Power: The creation of Armageddon* (Yale University Press, 1987) p. 187. This was not Arnold's first flirtation with 'robot' platforms. As a young major at the very end of the First World War, he had been sent to Europe by the US Army to persuade General Pershing, Commander of the American Expeditionary Force, to deploy its new, unmanned 'Kettering Bugs' against Germany. Charles Kettering had developed the aircraft in 1918 in association with Orville Wright.

‘robot, jet-propelled atomic bombs which will be guided by television and find their targets by radar.’<sup>8</sup> This was not (quite) a flight of fancy. In July 1944 the Air Force had trialled Project Aphrodite, in which war-weary B-17 Flying Fortresses filled with high explosive were supposed to be crashed onto targets in occupied Europe using television cameras mounted in their nose and remote (‘robot’) control from accompanying director aircraft.<sup>9</sup> Recalling that (as it happened, unsuccessful) experiment, Arnold repeated his conviction-prediction with renewed confidence:

‘One year ago we were guiding bombs by television, controlled by a man in a plane fifteen miles away. I think the time is coming when we won’t have any men in a bomber.’<sup>10</sup>

Baldwin thought the implication was obvious: ‘Robot planes, rockets, television and radar bombing and atomic bombs will do the work today done by fleets of thousands of piloted bombers.’ At first he tried to cut Arnold’s fantasy down to size. In his view, pilots would still be needed for photoreconnaissance and for ‘pin-point

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<sup>8</sup> Sidney Shalett, ‘Arnold reveals secret weapons, bomber surpassing all others’, *New York Times*, 18 August 1945. Indeed, when the cloud soared into the sky above Hiroshima, Tibbets’s co-pilot wrote they were like ‘Buck Rogers 25<sup>th</sup>-century warriors’: Ham, Hiroshima, p. 298.

<sup>9</sup> Walter J. Boyne, ‘The remote-control bombers’, *Air Force Magazine* 93 (11) (2010) 86-8; Conrad Crane, *Bombs, cities and civilians: American airpower strategy in World War II* (Wichita: University of Kansas Press, 1993) pp. 78-85; Timothy Schultz, *Redefining flight: How the predecessor of the United States Air Force transformed the relationship between airmen and aircraft* (Ph.D. dissertation, Duke University, 2007) pp. 193-249. The radio remote-control system could not handle take-offs and so crews took the aircraft up to 2,000 feet, handed control to operators in the ‘mother ship’ and then parachuted to safety over Britain. Only fifteen, unsuccessful missions were flown against V-1 missile launch sites and an expanded target list that included submarine pens and other targets inside Germany before the project was abandoned in January 1945.

<sup>10</sup> Shalett, ‘Arnold reveals’. Arnold thought that nuclear weapons were a mixed blessing, and in an essay ghost-written with William Shockley he noted that they had made destruction ‘too cheap and easy’ – one bomb and one aircraft could replace hundreds of bombs and vast fleets of bombers – and a similar concern is often raised by critics of today’s Predators and Reapers who argue that their remote, often covert operations have lowered the threshold for military violence.

visual bombing’<sup>11</sup> One year later found him more optimistic about the prospects for remote operations. ‘Today,’ Baldwin wrote in the *New York Times*, ‘planes without crews can be flown almost anywhere, and can even survive... the atomic cloud.’<sup>12</sup>

It was the need to ‘survive the atomic cloud’ that had persuaded the Air Force to accelerate the series of experiments which had captured Baldwin’s imagination. There were two pressing concerns. First, the Air Force was asked to conduct aerial photography and sampling of the atomic clouds produced in nuclear weapons tests, which raised new fears about the risks of radioactive contamination. Second, the next generation of nuclear weapons was going to be much bigger than Little Man or even Fat Boy, with a corresponding increase in the size of the shock wave, which raised alarms over the escape of the bombers delivering them. The solution to both dilemmas, the Air Force believed, was to be found in removing crews from the aircraft.

The first post-war series of nuclear tests, Operation Crossroads, took place in July 1946 at Bikini Atoll in the Marshall Islands. The target was a fleet of 95 ships ironically readied at Pearl Harbor and now anchored in the lagoon. This was an attempt by the US Navy to move centre stage after Hiroshima and Nagasaki – when the Air Force had played the leading role – and to establish that sea power was still relevant in the atomic age. But critics inside and outside Congress doubted the value of the tests: the bombs would be of the same type as Fat Man, so no development in weapons technology was involved, and in any event surface ships were unlikely to be the targets of such devastating weapons.<sup>13</sup> They dismissed

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<sup>11</sup> Hanson W. Baldwin, ‘The Atom Bomb and Future War’, *Life*, 20 August 1945.

<sup>12</sup> Baldwin, ‘The “Drone”’.

<sup>13</sup> In fact the first high-level meeting convened to discuss nuclear targeting in May 1943 had tentatively agreed that the best target for the bomb would be the Japanese fleet at anchor in Truk Lagoon in the central Pacific, a reverse Pearl Harbor, but Oppenheimer concluded that an air blast would be of ‘negligible usefulness against ships’; work continued on underwater blasts at Los Alamos, but the thrust of the Manhattan Project was directed towards the development of an air-burst weapon to be used against cities: Sean Molloy, “‘The rules of civilized warfare’: scientists,

Crossroads as an expensive, purely theatrical extravaganza. And despite the remote location, 4,000 miles from San Francisco, every effort was made to attract international attention, both public and professional; the official record trumpeted that ‘never before had a nation fanfared its most secret weapon so closely before the eyes of the world.’<sup>14</sup> As far as the Air Force was concerned, however, Crossroads would be ‘a laboratory test’ and not a ‘bomb-versus-battleship stunt’.<sup>15</sup> It would involve not only bomb delivery by one of its B-29 Superfortresses but also cloud monitoring by drones. Vice-Admiral William Blaney, commander of Crossroads, explained that ‘robot aircraft will dive into the atomic blast to gather scientific data’ and ‘uncover facts of radioactive phenomena as well as supply data on blast effects on airborne aircraft.’<sup>16</sup> His Air Force deputy abandoned sober-sided science for high drama. ‘Almost as dramatic as the flight of the B-29 bomber’, Major-General William Kepner told reporters, ‘will be the plunge of the unpiloted but mothered drone planes into the sky-reaching, irradiated cloud.’ ‘Where men cannot go,’ he enthused, ‘the drone will take electronic and other recording instruments.’<sup>17</sup>

In fact, the drones were supplied by both the Air Force and the Navy. For its part, the Air Force retained its love affair with the heavy bombers that had driven Aphrodite. This time its Drones Unit utilised new B-17 Flying Fortresses: four were converted into drones operated by radio-control from four others flying at a safe distance, while one acted as the master control aircraft. The drones were stripped of all their defensive armaments and fitted with radio and television equipment; air filters were fixed to their top turrets to trap particles from the cloud and collection bags installed in their bomb bays. Ground controllers launched the drones from

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soldiers, civilians and American nuclear targeting, 1940-1945’, *Journal of strategic studies* 30 (2007) 475-512: 483-6.

<sup>14</sup> W.A. Shurcliff, *Bombs at Bikini: the official report of Operation Crossroads* (New York: Wise & Co, 1947) p. 33. Print and broadcast journalists were allowed to file uncensored reports but all photographs were screened for security purposes.

<sup>15</sup> Sidney Shalett, ‘Atomic bomb test no “stunt” to AAF’, *New York Times*, 21 February 1946.

<sup>16</sup> ‘Drones will dive into atomic blast’, *New York Times*, 15 February 1946.

<sup>17</sup> Anthony Leveiro, ‘Fliers and robots to get atom data’, *New York Times*, 17 April 1946.

control jeeps and then handed off to the airborne controllers ('beeper pilots') on board the accompanying B-17s who directed the aircraft into the cloud before returning them to the ground controllers who managed the landing (Figure 2). The US Navy used its much smaller carrier-based Grumman F6F Hellcat fighter aircraft as drones and as control aircraft; the guidance system was essentially the same, and each of the drones had an air filter mounted under one of its wings. Altogether the Navy mustered 30 drones and 26 control aircraft (Figure 3).

The first shot in the series, codenamed Able, took place on 1 July 1946. At 0900 *Dave's Dream* dropped the bomb over the target fleet, but the result was not the thrilling spectacle that had been advertised. Visually it was a damp squib. Judged by its own Broadway razzamatazz, one reporter jibed, it was a complete flop: 'Operation Chloroform, the logical sequel to Operation Build-Up and Handout.'<sup>18</sup> Scientifically it was not much better. Although Vice-Admiral Blaney initially declared that the bomb was dropped 'with very good accuracy', it detonated 2,000 feet off-target – an error investigated by Tibbets himself<sup>19</sup> – exploding over one of the instrumentation vessels and compromising the readings from many others. Even most of the high-speed cameras missed the shot. One critic concluded that 'from the standpoint of pure science no test was ever more haphazard.'<sup>20</sup>

Against this catalogue of errors, which was glossed over in the official report, the aerial sampling missions were judged a considerable success. As soon as the

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<sup>18</sup> Jonathan Weisgall, *Operation Crossroads: the atomic tests at Bikini Atoll* (Annapolis MD: Naval Institute Press, 1994) p. 187. The second (underwater) shot in the series, codenamed Baker, more than made up for Able's lack of visual spectacle.

<sup>19</sup> The strange shape of the Fat Man bombs had bedeviled the efforts of practice crews to hit their targets (the original missed its aiming point over Nagasaki too), but Tibbets – who had been denied permission to drop the bomb for Able – subsequently showed that the crew of *Dave's Dream* had failed to make the proper corrections for wind speed and direction.

<sup>20</sup> Weisgall, *Operation Crossroads*, pp. 190-201; see also Keith Parsons and Robert Zaballa, *Bombing the Marshall Islands: A Cold War tragedy* (Cambridge: Cambridge University Press, 2017).

bomb was released the first B-17 control aircraft turned its huge drone (Fox) into the cloud at an altitude of 24,000 feet; Fox was then switched to its automatic pilot, entering the cloud eight minutes after the explosion, while the control aircraft raced around the cloud and resumed control when the drone emerged on the other side. Fox was followed by George (at 30,000 feet), How (at 18,000 feet) and Love (at 12,000 feet). All four drones were directed back to Eniwetok atoll where they were handed back to the ground controllers in jeeps at the end of the runway who taxied them to the radiological safe area where the filters and bags were removed and flown to Los Alamos Laboratory for analysis. The Navy launched four of its Hellcat drones from the carrier *Shangri-La*, accompanied by eight primary control aircraft and eight secondaries, but only three of the drones – Yellow, White and Blue – sampled the cloud at 5,000, 10,000 and 15,000 feet before being directed back to Roi Island for ground landing and sample recovery.<sup>21</sup>

The official report emphasised that the sampling programme was a notable first. ‘At Hiroshima and Nagasaki a few photographs and pressure measurements were made of the explosions, but almost nothing of value to physicists was learned.’<sup>22</sup> Crossroads had changed that; ‘for the first time, samples had been taken from an atomic cloud’ during what one military engineer hailed as ‘the most hugely instrumented experiment in history’.<sup>23</sup> To the Air Force its drones had made the

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<sup>21</sup> The Navy also operated a fleet of ‘drone boats’ to collect water samples from the lagoon.

<sup>22</sup> Shurcliff, *Bombs over Bikini*, p. 7; this was confirmed by Robert Jackson, ‘Guide to US Atmospheric Nuclear Weapons Effects Data’ (US Defense Nuclear Agency, December 1993). This later report noted that for the first (Trinity) test, ‘nuclear-effects-related activities were understandably limited’ because ‘the overwhelming issue for scientists was whether the bomb would work as predicted’ (p. 2-1); for Hiroshima and Nagasaki, he explained, the focus was on physical damage and biomedical effects after the blasts. In his view, therefore, Crossroads was ‘the first nuclear weapons effects series’ (p. 4-1).

<sup>23</sup> Leland B. Taylor, *History of Air Force Atomic Cloud Sampling, AFSC Historical Publication Series 61-142-1* (original: January 1963); Jack De Ment, ‘Instruments of Operation Crossroads’, *The Military Engineer* 39 (261) (1947) 414-419: 414. It was also the most thoroughly photographed experiment. Weigall, *Crossroads*, claims that ‘half the world’s supply of film was at Bikini’ (p. 121), and the Air

crucial contribution not only to the aerial sampling programme but also to the development of remote operations more generally: ‘For the first time, four-motored drone aircraft had been flown without a safety pilot aboard.’<sup>24</sup> The author of the official report was equally impressed. ‘With no one aboard,’ he marvelled, ‘these great planes were radio-guided through their prescribed flights across the target area, a unique and impressive feat.’ In a footnote he continued:

‘A number of Army Air Forces officials believe that the drone-plane program undertaken for Crossroads advanced the science of drone-plane operations by a year or more... Operation Crossroads was the first operation in which take-off, flight, and landing were accomplished with no one aboard. The feat was an impressive one; many experts had thought it could never be accomplished with planes of this size.’<sup>25</sup>

These were the experiments that had captured Baldwin’s imagination. At Bikini the drones were controlled over distance of eight miles or less, but Baldwin had been told that remote control up to fifty and perhaps even 100 miles was possible. These were what today would be called line-of-sight operations, so their range was limited and Baldwin stressed that, for the time being at least, ‘an unmanned drone cannot be sent careening into a target in Europe by an operator standing at his “beep box” on La Guardia field in New York’.<sup>26</sup> But he was also adamant that a threshold had been crossed:

‘In the Pacific so much experience in the handling of drones was accumulated during the summer and the operations were so far in advance of drone operations during the war that it is safe to say that a

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Force supplied ‘the world’s largest aerial camera’, mounted on a B-29 and ‘capable of recording on film the dial of a wrist-watch a quarter of a mile away’: De Ment, ‘Instruments’, 418.

<sup>24</sup> Taylor, *History*, pp. 8-9.

<sup>25</sup> Shurcliff, *Bombs at Bikini*, p. 98.

<sup>26</sup> Baldwin, ‘The “Drone”’.

simplified and reliable system of drone control – with all that implies – has been achieved.... Drones thus add a new and dangerous instrument to the growing armory of Mars, increase the power of the offensive and further complicate the tasks of the defensive.’<sup>27</sup>

Baldwin turned out to be right, but the remote sampling programme was not without its problems. In the Crossroads series of tests some Air Force drones were damaged by the shock wave, and there were difficulties of coordination between drones and their control aircraft. The controllers of the Navy drones described their charges as ‘cantankerous little children’: apart from the three that returned safely with their samples, another ‘refused to respond to its “mother plane’s orders” to come home’ and ‘took off in the direction of China’ – it was presumed to have crashed – while two others were lost before the blast ‘when they did not respond to radio control.’<sup>28</sup> The second and third series (Operation Sandstone in 1948 and Operation Greenhouse in 1951) were weapons development tests that involved new bombs with a composite core of uranium and plutonium that could be mass-produced for a projected nuclear arsenal. The Atomic Energy Commission requested an increase in the number of remote samplers for both series, but the mishaps continued. Some drones stopped responding to radio signals from their control aircraft altogether, and while most were recovered by the master control aircraft at least three crashed and exploded. After Sandstone the Air Force recommended the establishment of a permanent drone fleet to conduct sampling operations, but Greenhouse turned out to be the last series in which drones were used in the Pacific Proving Grounds. On 15 May 1948, during the final shot (Zebra) of Sandstone, Lieutenant-Colonel Paul Fackler, whose B-29 aircraft was charged with collecting samples ten miles from the detonation point, was unable to escape the advancing cloud. ‘No one keeled over dead, and no one got sick,’ he boasted later, and as soon as his radiation safety officer declared the crew had

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<sup>27</sup> Baldwin, ‘The “Drone”’.

<sup>28</sup> ‘All but one Bikini drone survive after sampling the angry atomic cloud’, *New York Times*, 2 July 1946.

reached its exposure limit Fackler turned the B-29, flew through rain showers to wash off radioactive particles and landed without incident. Afterwards Fackler pressed the case for crewed aircraft in place of drones, and for the last shots of Greenhouse two manned samplers supplemented the drones. By the time nuclear tests had been relocated from the Pacific to the Nevada Test Site the Air Force had decided that these conventional operations were acceptable and on occasion even superior. No longer a hit-or-miss affair in which the utility of the sample depended on 'pot-luck', an on-board pilot could manoeuvre the aircraft on approach and during cloud penetration to secure 'greater precision in sample size and location.'<sup>29</sup>

The phased transfer to the continental United States was a response to the pressure placed on the US military by its continuing logistical support for tests in the Pacific while the Cold War intensified and the Korean War raged.<sup>30</sup> Relocation raised questions other than the strategic and the scientific, of course: American public opinion had to be satisfied that there were no hazards to populations in the vicinity of the tests, and a refusal to allow crewed aircraft into the cloud could only have made that task more difficult.<sup>31</sup> Yet this did not mark the end of the use of

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<sup>29</sup> Taylor, *History*, p. 23; Mark Wolverton 'Into the Mushroom Cloud', [www.airspacemag.com](http://www.airspacemag.com), August 2009.

<sup>30</sup> Terrence R. Fehner & F. G. Gosling, *Battlefield of the Cold War: The Nevada Test Site*, Vol. 1: *Atmospheric Nuclear Weapons Testing 1951-1963* (US Department of Energy, 2006) pp. 35-44. The Armed Forces Special Weapons Project had sought to identify possible US sites since 1948. By 1950 the Pentagon feared that any expansion of the Korean War beyond the peninsula would threaten access to the western Pacific, and the Atomic Energy Commission recommended to the National Security Council that part of the Las Vegas Bombing and Gunnery Range be developed for nuclear tests. The first shot at the Nevada Test Site took place on 27 January 1951, but the Marshall Islands continued to be used for the most explosive tests until 1958.

<sup>31</sup> Similarly, US ground troops who were deployed to the Nevada Test Site during a series of exercises codenamed 'Desert Rock' between 1951 and 1957 were deliberately exposed to the blast and its radiation effects. During the Tumbler-Snapper George test on 1 June 1952, for example, troops were positioned in foxholes 7,000 yards from the blast; they were ordered to charge forward in battle formation as soon as the shock wave swept over their position – about 20 seconds – and to advance several thousand yards towards ground zero. See National Nuclear Security Information Photo Library (TS-52-77); *Operation Tumbler-Snapper 1952*

drones. Between 1951 and 1955 Lockheed F-80 jet aircraft were converted into drones and sent into atomic clouds over the Nevada Test Site to explore the effects of radiation exposure on live animals (monkeys and mice) and to assess the effects of blast on airframes. These were advertised as ‘NULLO’ flights (‘no live operator on board’). The drones were directed from control aircraft, but their approach and passage through the cloud was handled by ground control stations at Indian Springs Air Force Base 30 miles away (Figure 4). This was the Air Force portal for the Nevada Test Site, and since 2005 – renamed Creech Air Force Base – it has been the main control centre for the remote operation of Predators and Reapers over Afghanistan, Pakistan, Yemen and elsewhere. Their predecessors in the 1950s produced mixed results; there were several crashes and repeated failures to penetrate the cloud as planned, and crewed flights eventually replaced them.<sup>32</sup> When the Partial Nuclear Test Ban Treaty put an end to atmospheric testing in 1963 the need for aerial sampling over Nevada disappeared with the cloud.<sup>33</sup>

### **Atomic bombs and drones**

When *Dave’s Dream* dropped the bomb for the first shot of Crossroads, its pilot copied the *Enola Gay*’s manoeuvre over Hiroshima. As soon as the bomb doors were closed he threw the aircraft a tight 150-degree turn, dived and increased

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(US Atmospheric Nuclear Weapons Tests, Nuclear Test Personnel Review, DNA 6109F, 1952) at <http://www.dtic.mil/dtic/tr/fulltext/u2/a122242.pdf>; Advisory Committee on Human Radiation Experiments, Final Report (1995), Part II, Chapter 10.

<sup>32</sup> Fehner and Gosling, *Battlefield*, pp. 109-10, 144, 146; ‘Jet pilotless drones collect data on radiological hazards in atomic clouds’, *Electrical Engineer* 72 (6) (1953) 567; H.R. Everett, *Unmanned Systems of World Wars I and II* (Cambridge MA: MIT Press, 2015) pp. 564-9.

<sup>33</sup> It did not disappear over other locations; the Air Force continued crewed aerial sampling in order to monitor compliance with the Treaty, and today two of its aircraft supplement the satellite sensor network of the US Atomic Energy Detection System. The Constant Phoenix program has been deployed to measure radioactivity from both the Chernobyl and Fukushima incidents, and to monitor North Korea’s nuclear testing program.

speed to get away from the shock wave.<sup>34</sup> But this escape hatch would not be open for much longer. Once the decision had been taken to develop the next generation of thermonuclear weapons it was clear that the Air Force would have to deliver a vastly more powerful hydrogen bomb over a distance of 4,000 miles: ‘It was expected that the package would produce a lethal area so great that, were it released in a normal manner, the carrier would not survive the explosion.’<sup>35</sup> The production programme had to proceed with all possible speed since the Soviet Union had conducted its first successful atomic test on 29 August 1949. But the guided missiles the Air Force had in development were at least two years away. Only three aircraft in its current fleet met the operational criteria, and the Air Force decided to convert one of the B-47 Stratojet bombers due to be delivered by Boeing the following year into a drone capable of carrying the bomb. The project was codenamed ‘Brass Ring’. Its ultimate objective was ‘to fashion a B-47 carrier with completely automatic operation from take-off to bomb drop’, but this was such a tall order that the immediate plan called for an accompanying B-47 to act as a director aircraft to control take off, climb and cruise. The crew on the director aircraft would then set the automatic pilot on the carrier, which would either execute a standard bombing run or dive onto its target.<sup>36</sup> By February 1951 progress was still slow but the team was ordered to press on because ‘it has not been definitively established as yet that manned aircraft can safely deliver the weapon.’<sup>37</sup>

Brass Ring was a re-run of Aphrodite on an exorbitantly increased scale – and within infinitely higher stakes – and the problems facing the post-war project team were far greater. In October 1951 they discovered that their task had swollen far beyond its original, taxing specifications: ‘the super-bomb’ would weigh not 10,000 but 50,000 lbs. The B-47 would now have to be refuelled twice in mid-air to travel the projected distance. They modified their plans and planes accordingly, and

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<sup>34</sup> Shurcliff, *Bombs at Bikini*, p. 105.

<sup>35</sup> Delmer J. Trester, *Thermonuclear weapon delivery by unmanned B-47: Project Brass Ring (A history of the Air Force Atomic Energy Program)* p. 275.

<sup>36</sup> Trester, ‘Thermonuclear weapon delivery’, p. 291.

<sup>37</sup> Trester, ‘Thermonuclear weapon delivery’, p. 297.

after a series of setbacks the first hour-long test flight of the B-47 carrier on 10 March 1953 was successful:

‘The automatic take-off, climb and cruise sequence was initiated remotely from a ground control station. The aircraft azimuth, during take-off, was controlled by an auxiliary control station at the end of the runway. Subsequent maneuvers, descent and landing (including remote release of a drag parachute and application of brakes) were accomplished from the ground control station.’<sup>38</sup>

But there were ‘several aspects – certain level flight conditions, turn characteristics and the suitability of the aircraft as a “bombing platform” – which required further investigation.’ These were hardly minor tweaks. Completion of the project had already been delayed by a year and then extended to the end of December 1953, but Brass Ring was abandoned months before the deadline. Not only was much more work needed, but costs had spiralled, the expansion of US bases overseas had contracted the required delivery range, and the Air Force was finally convinced that a crewed aircraft could execute the bombing run safely (at least, for those on board).

Meanwhile, the Navy had not deserted the field. During the war its pilots had taken part in Project Aphrodite – tragically in one case<sup>39</sup> – and after Crossroads it reverted to its interest in directing small drones filled with bombs into enemy targets. In 1951 an anonymous officer writing in *Naval Aviation News* suggested that tomorrow’s drone ‘may have a television camera in the nose, carry a heavy bomb load and do a Kamikaze dive on a target with great efficiency.’<sup>40</sup> The following April a contributor to *Popular Mechanics* was invited to the Navy’s

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<sup>38</sup> Trester, ‘Thermonuclear weapon delivery’, pp. 349-50.

<sup>39</sup> Roger Connor, ‘Remembering the death of Lt Joe Kennedy Jr and America’s first combat drones’, Smithsonian National Air and Space Museum, 19 August 2014 at <https://airandspace.si.edu/stories/editorial/remembering-death-lt-joe-kennedy-jr-and-america's-first-combat-drones>.

<sup>40</sup> ‘Radio robots’, *Naval Aviation News*, July 1951, pp. 1-5.

Pilotless Aircraft Laboratory to observe a flight of four Hellcat drones controlled from a single aircraft. Although he said the Navy was ‘tight-lipped’ about its plans for the Hellcats, Herbert Johansen went beyond the *News*’s muted speculation to imagine a future in which the drones would ‘carry atomic warheads and crash-dive as projectiles of destruction.’<sup>41</sup> Perhaps this was his own, wild conjecture; perhaps not. The United States had already made it clear that it was prepared to use nuclear weapons in the Korean War, and later that year a naval officer who was overseeing an experiment in remote operations off the coast of North Korea conjured up exactly the same prospect. Between 28 August and 2 September 1952 six Hellcat drones on the USS *Boxer* were loaded with 2,000 lb bombs and, through television pods slung under their wings, yoked to control aircraft – AD-2Q Skyraiders this time – whose pilots used their screens to guide what were now described as ‘robot missiles’ on to their targets. An American agency reporter cabled a vivid description of what he called ‘one of the most dramatic and historical events of the Korean War’:

‘As the doomed craft streaked towards its target, grim-faced electronic experts, in a secret room on this ship, rode with the missile, mile by mile, through wondrous electronic instruments. On their dials in the secret room, the experts crossed the Sea of Japan and watched the jagged peaks of Eastern Korea loom in the distance and grow larger. Far from the missile, an automatic device transmitted every dying moment of the missile’s last hour to the USS *Boxer*.

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<sup>41</sup> Herbert Johansen, ‘No Live Operator Aboard’, *Popular Mechanics* 160 (4) (1952). Just two years before *Crossroads* the Navy’s Project Option had experimented with TDR-1 drones loaded with 500-2000 lb bombs and equipped with nose-mounted TV cameras controlled from the back seat of an Avenger Torpedo bomber. Its Special Task Air Group used the drones to attack targets of opportunity throughout the Solomon Islands between 27 September and 26 October 1944. As with *Aphrodite*’s larger bombers, these were all kamikaze missions of sorts, in which the unoccupied aircraft plunged into its target and exploded.

‘The target – an enemy concentration in a valley between two shadowy hills – was indicated on the receiving instrument – a real flak-ridden trap for any hapless Allied pilot. A second to go now – the signal of the instruments grew stronger as the guided missile dived straight at the target at hundreds of miles an hour. Then the instruments went suddenly blank.’

With that blank screen, he continued, those on board the *Boxer* knew that ‘here at last in actual combat, was a new era of battle’, when ‘electronic brains will ride in tough, dangerous places, saving the lives of American pilots.’<sup>42</sup>

The experiment was not a complete success. Only one of the six drones hit its target and the others all recorded near-misses, but this was enough for Lt Cdr Lawrence Kurtz, the remarkably loose-lipped) commander of Guided Missile Unit 90 responsible for the trial to boast that the United States had enough of them to ‘launch and sustain a large-scale robot campaign’. He then added this sensational rider: some of the ‘missile planes’ were ‘capable of carrying an atomic bomb from one continent to another.’<sup>43</sup> The agency report of his comments was played down in the United States, where they evidently incurred the wrath of his superiors. Rear Admiral John Sides described the use of the Hellcat drones as an ‘interim measure’ before the development of ‘more effective guided missiles’, conceding that ‘it wouldn’t take much imagination to realize that there are better ways of doing this job.’ He gave no further details: the Navy was ‘investigating the use of classified information in news dispatches on the employment of pilotless bombers in Korea’,

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<sup>42</sup> ‘United States ready for push-button warfare’, *Canberra Times*, 19 September 1952. His agency dispatch was dated 1 September but delayed and censored; it was published in several regional newspapers in the United States and in the Australian press almost three weeks later.

<sup>43</sup> ‘United States ready for push-button warfare’, *Canberra Times*, 19 September 1952; ‘Guided missiles in Korean War: Deadly new US technique’, *Sydney Morning Herald*, 19 September 1952.

but refused to elaborate.<sup>44</sup> Instead, Sides switched the focus from the aircraft to American lives. The object of the experimental programme observed by Johansen earlier in the year was ‘to obtain air kills by individuals operating from beyond the range of the enemy’s armament’, he emphasised, and in Korea ‘a controller sitting in relative safety’ outside the range of anti-aircraft defences ‘had been able to direct an effective drop on the enemy positions.’ A report in the *New York Times* had already underlined the significance: ‘The planes were sacrificed but, of course, not a man was lost.’<sup>45</sup>

And this was the larger and sharper point. The reason drones were originally used to fly through the atomic cloud; the reason the Air Force had sought a remotely operated aircraft to drop the next generation of nuclear weapons; the reason the Navy wanted ‘offensive drones’ and ‘robot missiles’ to attack heavily defended targets was to save the lives of American crews. It is the same mission that continues today in the US development of remote operations to prosecute its avowedly asymmetric wars: what the Air Force calls ‘projecting power without vulnerability’.

### **American Hiroshimas**

There was a second, astonishing American response to the attacks on Hiroshima and Nagasaki: a preoccupation with the vulnerability of its own cities to nuclear attack. ‘Physically untouched by the war’ – apart from Pearl Harbor – Paul Boyer notes that

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<sup>44</sup> ‘Korea robot raids “interim measure”’, *New York Times*, 19 September 1952. I don’t know if there were ever any serious plans to arm those ‘robot planes’ with nuclear weapons. Land-based guided missiles would eventually become one component of America’s nuclear triad, alongside the Air Force’s strategic bombers and the Navy’s submarines, but as I show below the development of drones took different directions.

<sup>45</sup> ‘Navy uses robot missiles against targets in Korea’, *New York Times*, 18 September 1952.

‘the United States at the moment of victory perceived itself as naked and vulnerable. Sole possessors and users of a devastating instrument of mass destruction, Americans envisioned themselves not as a potential threat to other peoples, but as potential victims.’<sup>46</sup>

And for all the appeals to Buck Rogers in commentaries on future ‘push-button’ wars, most of the scenarios presented to an anxious American public were based on military-scientific data (however imperfect these turned out to be).

On 19 November 1945, barely 100 days after Hiroshima, *Life* published an illustrated essay entitled ‘The 36-Hour War’, which was informed by a report from General Arnold as commander of the US Army Air Force to the Secretary of War. Although the opening paragraphs predicted that in the future ‘hostilities would begin with the explosion of atomic bombs on cities like London, Paris, Moscow or Washington’ – Arnold’s report had warned that ‘the danger zone of modern war is not restricted to battle lines’ and that ‘no one is immune from the ravages of war’<sup>47</sup> – the global allusion of the text was dwarfed by Alexander Leydenfrost’s striking illustration of ‘a shower of white-hot rockets’ falling on Washington DC. In case any reader should doubt the location of what the strapline called ‘the catastrophe of the next great conflict’, the next image sprawled across two pages and presented a vast panorama looking east across the United States from 3,000 miles above the Pacific: ‘Within a few seconds atomic bombs have exploded over New York, Chicago, San Francisco, Los Angeles, Philadelphia, Boulder Dam, New Orleans, Denver, Washington, Salt Lake City, Seattle, Kansas and Knoxville (sic)’ killing 10,000,000 people (Figure 5). Arnold’s report had suggested that there were ‘insurmountable difficulties in an active defense against future atomic projectiles.’ Now *Life* warned that ‘low-flying robot planes’ were even more dangerous because

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<sup>46</sup> Paul Boyer, *By the Bomb’s early light: American thought and culture at the dawn of the atomic age* (New York: Pantheon, 1985) p. 15.

<sup>47</sup> Third Report of the Commanding General of the Army Air Force to the Secretary of War (12 November 1945), p. 59

they would be more difficult to detect by radar – and ‘radar would be no proof at all against time bombs of atomic explosive which enemy agents might assemble in the U.S’ – so that defence was more or less impossible. A counterattack could be launched (against an enemy who remained unidentified throughout the essay), but nuclear strikes would surely be followed by invasion. By then, the US would have suffered ‘terrifying damage’: ‘All cities of more than 50,000 have been levelled’ and New York’s Fifth Avenue reduced to a ‘lane through the debris’ (Figure 6).<sup>48</sup>

That final image was unique; it was the only one to envision a nuclear attack from the ground. Perhaps that was unsurprising; the power of the image – ‘the nuclear sublime’ – was one of the central objectives of the attacks on Hiroshima and Nagasaki. ‘The weapon’s devastating power had to be seen to be believed,’ Kyo Maclear observed, in Moscow as well as in Tokyo. And above all, literally so, it was designed to be seen from the air. During the seven years of the US occupation of Japan the effects on the people who lived and died in the irradiated rubble were subject to strict censorship. Still photographs could not be published – professionals and amateurs were ordered to burn their films and prints (fortunately some refused and hid them instead) – while Japanese media and even US military film crews had their documentary footage embargoed.<sup>49</sup> In their place were endless images of the vast cloud towering into the sky. In fact *Life* had published a series of aerial views of the ‘obliteration’ of Hiroshima and the ‘disembowelling’ of Nagasaki just three months before its speculations on the 36-hour war.<sup>50</sup> All those high-altitude views,

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<sup>48</sup> ‘The 36-Hour War: Arnold report hints at the catastrophe of the next great conflict’, *Life*, 19 November 1945, pp. 27-35; see also Alex Wellerstein, ‘The 36-Hour War’, *Restricted Data*, at <http://blog.nuclearsecrecy.com/2013/04/05/the-36-hour-war-life-magazine-1945>, 5 April 2013.

<sup>49</sup> Kyo Maclear, *Beclouded visions: Hiroshima-Nagasaki and the art of witness* (New York: SUNY Press, 1998); Barbara Marcon, ‘Hiroshima and Nagasaki in the eye of the camera’, *Third Text* 25 (6) (2011) 787-97.

<sup>50</sup> ‘War’s ending’, *Life*, 20 August 1945, pp. 25-31. In an accompanying editorial on ‘The Atomic Age’, the unease of the magazine about the effects of the twin bombings haunted its uncertain prose. ‘Every step in [the] bomber’s progress has been more cruel than the last,’ the editors wrote. ‘From the very concept of strategic bombing, all the developments – night, pattern, saturation, area,

and the maps that accompanied them, planed away the field of bodies: all that could be seen, deliberately so, were levelled spaces and superimposed concentric circles. In the studied absence of a visual record it was left to the imagination of writers to convey the effect of the bombs on human beings.<sup>51</sup> And yet, as often as not, it was the bodies of Americans that filled the frame.

Philip Morrison's remarkable essay for the Federation of American Scientists was at once the best informed and the most exemplary. Morrison was a former student of Oppenheimer who had worked with him on the Manhattan Project, and in July 1945 he was sent to the Mariana Islands as part of the team charged with assembling Little Boy. One month later he was on the ground in Hiroshima with the US Army mission to investigate the effects of the bomb. Their report was submitted in June 1946, but Morrison's personal essay had appeared three months earlier and had already acknowledged the impossibility of conveying the enormity of the scene in dry and distanced scientific prose. It also proposed a solution.

'Even from pictures of the damage realization is abstract and remote. A clearer and truer understanding can be gained from thinking of the bomb as falling on a city, among buildings and people, which Americans know well. The diversity of awful experience which I saw at Hiroshima ... I shall project on to an American target.'

Warning that in any future war there would be twenty such targets – and not one bomb but 'hundreds, even thousands' – Morrison, as befitted someone who served

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indiscriminate – have led straight to Hiroshima, and Hiroshima was and was intended to be almost pure *Schrecklichkeit* [terror]. The use of the German was deliberate; noting that the Hague 'rules of war' had been persistently violated during the war by both sides, the editorial insisted that 'Americans, no less than Germans, have emerged from the tunnel with radically different standards and practices of permissible behaviour toward others' (p. 32).

<sup>51</sup> It was this artfully staged geometry of destruction that enabled some apologists to treat Hiroshima and Nagasaki as no different from other Japanese cities that had been subject to US firebombing, and to erase the suffering of the victims of both air campaigns from the field of view.

with the US Army's Manhattan Engineer District, selected Manhattan.

'The device detonated about half a mile in the air, just above the corner of Third Avenue and East 20<sup>th</sup> Street, near Grammercy Park. Evidently there had been no special target chosen, just Manhattan and its people. The flash startled every New Yorker out of doors from Coney Island to Van Cortland Park, and in the minute it took the sound to travel over the whole great city, millions understood dimly what had happened.'

After an endless chamber of horrors – bodies of old men 'charred black on the side towards the bomb', men with clothing in flames, women with 'red and blackened burns', and 'dead children caught while hurrying home'; toppled brownstones, roads choked with rubble – he concluded that at least 300,000 people would have died: 200,000 'burned and cremated' by volunteers, and the rest 'still in the ruins, or burned to vapour and ash.'<sup>52</sup>

Hard on the heels of the Army in Hiroshima was the US Strategic Bombing Survey, whose findings were rendered in the same, impersonal voice that Morrison found wanting. But in the concluding section of its report, the authors confessed that investigators had been bothered by the same troubling question as Morrison: 'What if the target for the bomb had been an American city?'<sup>53</sup> They provided rough and ready answers, which they accepted had 'a different sort of validity' from the measurable data used in the preceding sections, but they insisted that their speculative calculations were 'not the least important part of this report' and that they were offered 'with no less conviction.' Acknowledging substantial differences

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<sup>52</sup> Philip Morrison, 'If the bomb gets out of hand', in *One world or none* (Federation of American Scientists, 1946) pp. 1-15; cf. *The Atomic Bombings of Hiroshima and Nagasaki*, Manhattan Engineer District, US Army, 29 June 1946, at <http://www.atomicarchive.com/Docs/MED/index.shtml>.

<sup>53</sup> 'That the Survey had seldom, if ever, felt compelled to ask such a question as it pored over the ruins of Germany spoke to the sheer psychic effect of the magnitude of the new weapon': Tom Vanderbilt, *Survival City: Adventures among the ruins of Atomic America* (Princeton: Princeton Architectural Press, 2002) p. 74.

between Japanese and American cities, the report none the less concluded that most buildings in American cities would not withstand an atomic bomb bursting a mile or a mile and a half from them, and that the vertical densities of high-rise buildings would produce large numbers of dead, injured and desperately sick people: ‘The casualty rates at Hiroshima and Nagasaki, applied to the massed inhabitants of Manhattan, Brooklyn, and the Bronx, yield a grim conclusion.’<sup>54</sup>

The most vivid, visceral contrast to the dry recitations of the official reports appeared on 31 August 1946, when the *New Yorker* devoted an entire issue to John Hersey’s epic essay on Hiroshima. It was based on interviews he had conducted with more than 40 survivors over three weeks in April. Written when he returned to New York, beyond the scrutiny of military censors, Hersey focused on six people whose stories he told in spare, unadorned prose (he later said he chose to be ‘deliberately quiet’ so that ‘the horror could be presented as directly as possible’). The essay was cinematic in its execution, cutting from individual to individual across the shattered city, and excruciating in its painstaking detail. Their splintered accounts combined a methodical matter-of-factness – the numbing one-thing-after-another of their acts of survival – with the almost unspeakable horror of what lay beyond: ‘Under many houses, people screamed for help, but no one helped; in general, survivors that day assisted only their relatives or immediate neighbors, for they could not comprehend or tolerate a wider circle of misery.’ Two of Hersey’s respondents were doctors, which enabled him to pan out across that vast sea of casualties (‘Wounded people supported maimed people; disfigured families leaned together’) and then bring the focus back to individuals: ‘Tugged here and there in his stockinged feet, bewildered by the numbers, staggered by so much raw flesh, Dr.

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<sup>54</sup> *The effects of the atomic bombings of Hiroshima and Nagasaki* (US Strategic Bombing Survey, submitted 19 June 1946; published version 30 June 1946) pp. 39-41. The published version included a selection of photographs, virtually all of them aerial views, and the only photograph showing a victim was of a Japanese soldier with superficial burns: bodies were rendered as biomedical objects. Although most of the images obtained by the Survey remained classified, many of them are now available in David Monteyne, Adam Harrison Levy and John Dower (eds) *Hiroshima Ground Zero 1945* (Göttingen: Steidl, 2011).

Sasaki lost all sense of profession and stopped working as a skillful surgeon and a sympathetic man; he became an automaton, mechanically wiping, daubing, winding, wiping, daubing, winding.’ Hersey’s narrative moved carefully through the weeks after the blast until the results of radiation sickness began to take their toll and even the signs of a precarious normality became sinister: ‘a blanket of fresh, vivid, lush, optimistic green’ as wild flowers bloomed ‘among the city’s bones.’<sup>55</sup>

Surely this awful litany would turn the American public’s post-atomic eyes to Japan? In fact the extraordinary success of Hersey’s essay – the print run of 300,000 sold out, ‘Hiroshima’ was reprinted in many newspapers, broadcast on the radio in nightly instalments, and when it appeared in book form it became an immediate bestseller – served not only to dispel the claims of those who had sought to minimise the horrors of Hiroshima and Nagasaki; it also redoubled the fears of an attack on the continental United States. In consequence, it was not only the *New Yorker* but also New York that dominated the American atomic imaginary in the late 1940s and 50s. Even the first mass-market edition of *Hiroshima* confirmed that the preoccupation with American lives had not sensibly diminished. Hersey later said he had wanted his readers ‘to identify with the characters in a direct way’ – ‘to become the characters enough to suffer some of the pain’<sup>56</sup> – but the artist responsible for the cover of the paperback, Geoffrey Biggs, took that literally. His image showed what he described as ‘two perfectly ordinary people’ in ‘a city like

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<sup>55</sup> John Hersey, ‘Hiroshima’, *New Yorker*, 31 August 1946. Hersey later explained that he wanted ‘to write about what happened not to buildings but to bodies’ and ‘cast about for a form to do that’; he found it on the marchlands between T.S. Eliot’s *The Wasteland* and Thornton Wilder’s *The Bridge of San Luis Rey* (which he read onboard ship on his way to Japan). See John Hersey, ‘The Art of Fiction No 92’ (interview with Jonathan Dee), *The Paris Review* 100 (1986) 1-23. For commentaries, see Dan Gerstle, ‘John Hersey and Hiroshima’, *Dissent* 59 (2) (2012) 90-94; Patrick Sharp, ‘From Yellow Peril to Japanese wasteland’, *Twentieth Century Literature* 46 (2000) 434-52; Michael Yaavenditti, ‘John Hersey and the American conscience: the reception of “Hiroshima”’, *Pacific Historical Review* 43 (1974) 24-49.

<sup>56</sup> The Bantam edition appeared in 1948; Hersey, ‘Art of fiction’.

yours or mine’: who happened to be Americans in an American city (Figure 7).<sup>57</sup>

The publication of ‘Hiroshima’ was preceded by the two tests at Bikini, and in 1947 the official report on Crossroads illustrated the vastly more spectacular effects of the second (Baker) shot by superimposing its towering cloud over Manhattan (Figure 8). Perhaps the most iconic series of images of a post-atomic New York was painted by Chesley Bonestell and Birney Lettick (Figure 9). They accompanied John Lear’s contribution to *Collier’s* in August 1950, whose title seemed to evoke Hersey’s essay only to transpose it: ‘Hiroshima USA’. A prefatory note from the editor William Davenport insisted that nothing in the report was fantasy. While ‘the opening account of an A-bombing of Manhattan may seem highly imaginative,’ he wrote, ‘little of it is invention.’ It was based on the two US military surveys of Hiroshima, interviews with officials at the Atomic Energy Commission and the Pentagon, and advice from physicists, engineers, doctors and other experts. The description that followed was apocalyptic:

‘Aerial reconnaissance was impractical immediately after the blast because of the cloud of black grime that masked the lower city. Even after that cleared, it was only possible for the police helicopter squad to get a numb impression of the devastation. Streets could not be seen plainly. Many were blotted out entirely. In an area roughly 15 blocks long and 20 blocks across – from Canal Street north to Tenth and from Avenue B to Sullivan Street – there was now an ugly brown-red scar. A monstrous scab defiling the earth...

‘Rising gradually outward from this utter ruin ... was all that was left of Manhattan between Thirty-Eighth Street and Battery Park.’<sup>58</sup>

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<sup>57</sup> Paula Rabinowitz, *American Pulp: how paperbacks brought modernism to Main Street* (Princeton NJ: Princeton University Press, 2014) p. 211.

<sup>58</sup> John Lear, ‘Hiroshima USA’, *Collier’s*, 5 August 1950, pp. 11-15, 60-63: 15.

As this passage implies, however, Lear's vantage point was far from Hersey's, who had described 'four square miles of reddish-brown scar, where everything had been buffeted down and burned' but who was clearly more invested in the suppurating wounds and scarred flesh of the survivors. Consistent with the official sources from which Lear drew, his emphasis was instead on the geometries of destruction: only here and there did the bodies of 'the burned, the crushed and the broken' flicker into view. Still, the sting was in the tail. 'Fortunately for all of us,' Lear concluded fifty pages after his editor's admonitory note, 'the report you have just read is fiction.' But 'if it ever does happen, the frightfulness will almost certainly be more apocalyptic than anything described in these pages.'

'For this documentary account is a conservative application to Manhattan Island of the minimum known consequences of explosion of *one* of the *1945 model* A-bombs. And the Russians, if they once decide to attack us, surely will drop two or three or four of the 1950 models, each of which would ruin almost twice the area here circumscribed... In fact, one of the primary assumptions of current military planning for defense of the United States is that an enemy's first move will be to try to disable not only New York but the entire Atlantic seaboard...' <sup>59</sup>

Similar scenarios were regularly offered for other cities, including Chicago in 1950, Washington in 1953, Houston in 1955 and Los Angeles in 1961, and all of them dramatized their accounts through photomontages, maps and artwork.

Significantly, the burden of these accounts was on the effects of blast, burn and destruction. Hersey's descriptions of radiation sickness in Hiroshima were not

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<sup>59</sup> Lear, 'Hiroshima USA', 62. One year later the magazine devoted an entire issue to 'The war we do not want' purporting to describe the defeat and occupation of the Soviet Union; the conflict was punctuated by air strikes on Chicago, Detroit, New York, Philadelphia and Washington and missiles launched from submarines against Boston, Los Angeles, Norfolk (Virginia), San Francisco, and Washington. There were also Soviet nuclear strikes on London and US saturation strikes on the Soviet Union: *Collier's*, 27 August 1951.

mirrored in the United States, where the government consistently minimized its dangers. For the benefit of the Joint Committee on Atomic Energy in February 1953 the Atomic Energy Commission superimposed the blast radius from the first hydrogen bomb detonated in the Marshall Islands the previous November ('Ivy Mike') over a map of Washington DC, and the conceit provoked laughter from members of Congress because the 'zero point' was centred on the White House not the Capitol. The high-yield thermonuclear blast of Castle Bravo on 1 March 1954 was of a different order, and its fallout contaminated thousands of square miles. To illustrate its extent the AEC superimposed the plume over the eastern seaboard of the United States. Had this bomb been detonated over Washington, then Philadelphia, Baltimore and New York would have become uninhabitable (Figure 10). President Eisenhower insisted on the map remaining classified, and when the *New York Times* splashed across its front page 'The H-Bomb can wipe out any city' its map was centred on New York and emphasised physical damage and destruction (Figure 11).<sup>60</sup>

I rehearse all this because in her reflections on 'the age of the world target' Rey Chow writes of 'the self-referential function of virtual worlding that was unleashed by the dropping of the atomic bombs, with the United States always occupying the position of the bomber, and other cultures always viewed as the ... target fields.'<sup>61</sup> Yet, as I have shown, a common – perhaps even the most common – American response to Hiroshima and Nagasaki in the years immediately after the

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<sup>60</sup> Richard Hewlett and Jack Holl, *Atoms for Peace and War 1953-1961: Eisenhower and the Atomic Energy Commission* (Berkeley CA: University of California Press, 1989) p. 181. The map followed a press conference held by Rear Admiral Lewis Strauss, chairman of the AEC, who explained that by 'any city' he meant 'the heart of Manhattan': William Laurence, 'Vast power bared', *New York Times*, 1 April 1954. Strauss also shared with the press part of the briefing he had given the President; his reported remarks minimised any dangers from radioactivity: 'any radioactivity falling into the test area would become harmless within a few miles': 'Text of statement and comments by Strauss on hydrogen bomb tests in the Pacific', *New York Times*, 1 April 1954.

<sup>61</sup> Rey Chow, in 'The age of the world target: atomic bombs, alterity, area studies', in her *The age of the world target: self-referentiality in warm theory and comparative work* (Durham: Duke University Press, 2006) pp. 25-43: 41.

war was precisely the opposite. To be sure, the preoccupation with American cities as targets was spectacularly self-referential. Peter Galison was not sure whether ‘the bombsight eye had already begun to look back’ before Hiroshima, but he had no doubt that analysts working in the atomic rubble started ‘to see America through the bombardier’s eye.’ In a further twist to the examples I have cited, he shows how this scopic regime was refracted so that US defence planning in the 1950s included a national programme of ‘self-targeting’ in which cities were required to transform large-scale maps of their communities into target zones for nuclear bombs: what Galison called a ‘new, bizarre yet pervasive form of Lacanian mirroring’.<sup>62</sup>

As it happened, nuclear-capable bombers repeatedly circled above American cities, which were indeed transformed into targets – for the US Air Force. Strategic Air Command staged a series of exercises over major cities to test its targeting capability. The first public demonstration was Operation Pacific on 16 May 1947. The *Times* cheerfully announced that ‘for forty seconds today New York City will be under the shadow of the most powerful bombing formation ever assembled in the United States.’ Every available B-29 Superfortress was to be involved; following a ‘split-second schedule’, 130 of the giant aircraft would rendezvous over – where else? Manhattan. But the hundreds of thousands of New Yorkers who turned out to watch the show were disappointed. Fewer aircraft arrived than had been expected, a result of poor weather and poor timing, which ‘destroyed the effect of a mass bombing’ that people ‘had been led to expect.’ The *Times* reckoned that ‘the crowd felt cheated’, but SAC’s commander insisted that this was always intended to be more than an air show: ‘Everybody should be tickled that we carried no bombs,’ he told reporters, ‘because New York City in the national picture is the No 1 target’.<sup>63</sup>

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<sup>62</sup> Peter Galison, ‘War against the center’, *Grey Room* 4 (2001) 5-33: 29-30.

<sup>63</sup> ‘130 bombers to visit the city in vast air maneuver today’, *New York Times*, 16 May 1947; Meyer Berger, ‘101 B-29s over city but bad weather spoils big air show’, *New York Times*, 17 May 1947. SAC tried again over Chicago in August but the results were even worse, and soon SAC’s exercises were shielded from the public gaze and relied on radar bomb scoring. This too subjected cities across the United States to simulated attacks. According to Eric Schlosser, SAC ‘staged mock attacks on every city in the United States with a population larger than twenty-five

As his warning implied, there was a fine line between instilling confidence in America's nuclear strike capability and inviting complacency about nuclear attack. To avoid that danger exercises of a different kind were conducted at the Nevada Test Site. Starting in 1953 mannequins were placed inside single-family wooden houses to calculate the survival prospects for what Joseph Masco calls the American 'nuclearized' family. The battered mannequins – Hersey's Hiroshima survivors materialized in plaster and transposed to the United States – were paraded at county fairs with the tag line: 'These mannikins could have been real people; in fact, they could have been you.'<sup>64</sup>

### **Predator and prey**

If these were all so many different versions of a nuclear narcissism, not everyone who contemplated 'Hiroshima USA' was an American. Fifty years later Osama bin Laden repeatedly invoked Hiroshima and Nagasaki in public messages and in clandestine communications. He did so partly as an indictment of what he saw as American hypocrisy over terrorism. Dropping atomic bombs on the two Japanese cities were acts of terrorism, he argued, 'whose victims included women, children and the elderly', and he complained that 'when people at the ends of the earth were killed by their hundreds and thousands, young and old, it was not considered a war crime.' But bin Laden also saw in Hiroshima a strategy: since the strikes had forced Japan to surrender, he believed 'a "Hiroshima" of at least 10,000

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thousand, practicing to drop atomic bombs on urban targets in the middle of the night. San Francisco was bombed more than six hundred times within a month'; Eric Schlosser, *Command and control: nuclear weapons, the Damascus accident and the illusion of control* (New York: Penguin, 2013). See also Derek Gregory, 'Bombing the USA', at <https://geographicalimagination.com/2016/02/02/bombing-the-usa>, 2 February 2016.

<sup>64</sup> Joseph Masco, *The Theater of Operations: National security affect from the Cold War to the War on Terror* (Durham NC: Duke University Press, 2014) p. 22.

During the war bombing runs had been staged against mock German and Japanese targets at the Dugway Proving Ground but the buildings had no occupants. As Tom Vanderbilt wryly remarks, now 'the inhabitants had been rewritten into the picture' because the objective was to calibrate the lives of Americans: Vanderbilt, *Survival city*, p. 93.

casualties' on American soil would compel the United States to withdraw its troops from the Middle East.<sup>65</sup> The terrorist attacks on 11 September 2001 involved civilian airliners not nuclear weapons, and American news media did not explicitly cite 'Hiroshima USA' – but they came uncomfortably close. Coverage of the aircraft crashed into the Pentagon was rapidly eclipsed by an unwavering focus on the strikes on the World Trade Center in Lower Manhattan; the scenes of terrified, ash-covered people running from the collapse of the Twin Towers prompted NBC's Tom Brokaw to say that it 'looks like a nuclear winter in Lower Manhattan'; and, in a rhetorical displacement of the epicentre of Hiroshima, the site of the ruined World Trade Center was dubbed 'Ground Zero'.<sup>66</sup>

Far from compelling a withdrawal of US forces 9/11 served only to redouble US military intervention in the region. By then the suspension of the Cold War had already transformed aerial violence. If the immediate threat to the United States now came from non-state terrorist organisations, principally but not exclusively al Qaeda and its affiliates, then saturation bombing was largely irrelevant (though it would still have its shocking place in the US-led invasions of Afghanistan and Iraq). As part of an evolving US counterterrorism and counterinsurgency strategy, a new dimension was added to the arsenal of later modern war, a granular form of killing directed not against cities but against individuals. One of its central vectors was the drone, but in a form – within an apparatus – far removed from its predecessors of the 1940s and 50s. The new drones were no longer adaptations of crewed aircraft but were specifically designed for remote operation. They required no accompanying director aircraft but were linked by Ku-band satellite and fibre-optic

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<sup>65</sup> Steve Coll, 'What Bin Laden sees in Hiroshima', *Washington Post*, 6 February 2005; John Dower, *Cultures of war: Pearl Harbor, Hiroshima, 9-11, Iraq* (New York: Norton/New Press, 2010), p. 87.

<sup>66</sup> Caryn James, 'A day of terror', *New York Times*, 12 September 2001; Gene Ray, 'Ground Zero: Hiroshima Haunts "9/11"', in his *Terror and the Sublime in Art and Critical Theory* (London: Palgrave, 2005) pp. 51-59. Lines of sight become blurred, of course: the other, probably even more frequent comparison – though it also drew the public gaze back to Japan – was with Pearl Harbor. See Dower, *Cultures of war*, p. 161; Amy Kaplan, 'Homeland insecurities: reflections on language and space', *Radical history review* 85 (2003) 82-93.

cable to ground control stations thousands of miles away. Their video transmissions were not limited to guidance information for their pilots but provided intelligence, surveillance and reconnaissance through full-motion video feeds accessible not only to ground control crews but also to observers distributed across a global network. And even when they were armed they were not disposable but recoverable platforms from which the Air Force claimed it could put ‘warheads on foreheads’.<sup>67</sup>

These developments were driven in part by the escalating manhunt for bin Laden, already under way before 9/11, and with them the ligatures between drones and Strategic Air Command – which were still in place during the Vietnam War<sup>68</sup> – were finally removed. The parent company whose aeronautics subsidiary supplied the US Air Force with its first purpose-built drone, the RQ-1 Predator, was involved in nuclear research, but apart from the name – General Atomics<sup>69</sup> – there seems to

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<sup>67</sup> Anna Mulrine, ‘Warheads on foreheads’, *Air Force Magazine* 91 (10) (2008) 44-47; see also Derek Gregory, ‘Moving targets and violent geographies’, in Heather Merrill and Lisa Hoffman (eds), *Spaces of danger: culture and power in the everyday* (Athens GA: University of Georgia Press, 2015) pp. 256-96.

<sup>68</sup> Tactical Air Command (since absorbed into Air Combat Command) had refused to be involved in any drone programme – its commander jibed that ‘when the Air Staff assigns 18-inch pilots to this command, I’ll reconsider the issue’ – and in the 1960s SAC used ‘Lightning Bugs’ – converted Firebee target drones – to conduct photoreconnaissance of China’s nuclear programme. The drones were launched from under the wing of DC-130 transport aircraft and followed pre-programmed routes before being recovered by parachute. The results were decidedly mixed but improved versions of the Bugs enjoyed more success in Vietnam, where they were flown in support of SAC’s non-nuclear bombing runs; some even transmitted real-time TV images back to the DC-130. By then the United States was toying with an ‘electronic battlefield’ in South East Asia, which for a short time included drones flying over the Ho Chi Minh Trail to relay signals from a distributed network of ground sensors. This was far from successful, but its conceptual armature – an integrated sensor-shooter system – was far more consequential for the future of drones than the Cold War platforms themselves. See Derek Gregory, ‘Lines of descent’, in Peter Adey, Mark Whitehead and Alison Williams (eds) *From above: the politics and practice of the view from the skies* (New York: Oxford University Press, 2014) pp. 41-69.

<sup>69</sup> General Atomics was founded in 1955 as a division of General Dynamics for research and development in the use of nuclear energy; soon after it became a full-blown defence contractor. The Predator has a complicated pre-history, but General Atomics announced the first test flight of its version in August 1994, ‘within six

have been no substantive connection between the two. Although the entanglements between drones and nuclear weapons became largely circumstantial, once the decision was taken to arm the Predator parallels to the previous experiments emerged to bedevil future deployments.

Like the drones used to sample the atomic cloud, the Predator was conceived as a monitoring platform; its function was to provide intelligence, surveillance and reconnaissance for attacks to be executed by other means. Early versions were used in the NATO air campaigns over the former Yugoslavia in the 1990s, where a number of major operational problems were resolved, but its enlistment in the CIA effort to trace and track bin Laden produced new challenges. At first the CIA's search relied on ground agents, communications intercepts and satellite imagery. In response to the terrorist attacks on the US embassies in Dar es Salaam and Nairobi in August 1998, the Clinton administration launched devastating Tomahawk cruise missile strikes from US submarines off the coast of Pakistan on an al Qaeda camp complex in Afghanistan and the al-Shifa pharmaceutical factory in Sudan. The second objective turned out to be spectacularly misjudged and the administration decided to proceed in the future with all possible caution. Alternative plans had also been put in place for bin Laden's capture by ground assault teams and for another missile strike on his presumed location, but these missions were called off because the CIA had chronic difficulty in securing definitive intelligence. The Predator appeared to offer the agency and the administration a way out. Uzbekistan gave permission for a sixty-day trial to be conducted from one of its air bases, but owing to the political sensitivity of Operation Afghan Eyes President Karimov demanded the lightest possible US footprint. Starting in September 2000 a forward-deployed USAF crew handled the Predator's launch and recovery from Karshin-Khanabad Air Base in Uzbekistan, while the flights over Afghanistan were directed via a satellite link from a ground control station at Ramstein Air Base in Germany.

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months of receiving a Pentagon contract to demonstrate an advanced concept unmanned aerial vehicle': see Richard Whittle, *Predator: the secret origins of the drone revolution* (New York: Henry Holt, 2014).

The Predator team was convinced it had captured bin Laden at least once, and perhaps on several other occasions, but these were all visual captures that triggered no military response.<sup>70</sup> The CIA briefly considered linking the Predator's video stream to the Navy submarines, but there would still be a six-hour delay between confirmation and execution that would introduce the same uncertainty that had scuttled previous missions. If the Predator could be armed, however, the response time could be reduced to seconds. And so new experiments were authorised, and once again a drone took to the skies over Indian Springs in Nevada. In a repeat of earlier fears about the survivability of the *Enola Gay* and its successors, there were doubts about the ability of the Predator's fragile airframe to withstand the shock of a Hellfire missile launched from under its wings. The CIA also wanted to calibrate the likely effects of a Hellfire strike on the occupants of a mud-brick compound like those found in rural Afghanistan (plywood cut-outs and watermelons substituted for the mannequins this time around).<sup>71</sup> Both tests were successful, but the description of the Korean War drones as 'robot missiles' returned to throw a wrench into the works. A debate raged over the scope of the Intermediate Range Nuclear Forces Treaty, which the United States had ratified in 1988, because it defined missiles as 'unmanned, self-propelled weapon-delivery vehicles' – which seemed to catch the armed Predator in its net. During the negotiations some Pentagon officials had wanted to limit the treaty to nuclear-armed systems – precisely in order to create a space for the future development of drones – but they were rebuffed, and when the Predator was deployed over the Balkans the Air Force had been warned off converting it to 'a weapon-delivery role'. The new situation must have been more compelling because State Department lawyers were now persuaded that the Predator was merely a platform and as such remained

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<sup>70</sup> For a far more sceptical view of the quality of the video feeds and the reliability of the visual identification, see Andrew Cockburn, *Kill-chain: the rise of the high-tech assassins* (New York: Henry Holt, 2015).

<sup>71</sup> Steve Coll, *Ghost wars: the secret history of the CIA, Afghanistan and bin Laden from the Soviet invasion to September 10 2001* (New York: Penguin, 2004); Whittle, Predator, pp. 171-83.

outside the scope of the Treaty. But they also argued that the Status of Forces Agreement with Germany would require Berlin's consent for the activation of an armed Predator, and so it was decided to relocate the ground control station to Indian Springs and connect it to the satellite portal at Ramstein through a fibre-optic cable under the Atlantic.<sup>72</sup>

Bad weather intervened, and in the absence of any agreed policy from the incoming Bush administration no Predator flights – armed or otherwise – took place over Afghanistan in the winter or spring of 2000-1. The first lethal strike by a Predator did not take place until after 9/11, when in a joint CIA-CENTCOM operation Hellfire missiles were launched against the leader of the Afghan Taliban, Mullah Omar, in a house near Kandahar on 7 October 2001.<sup>73</sup> Although the strike was unsuccessful, the science-fiction future that had been conjured up only to be dismissed by Hanson Baldwin more than fifty years earlier, of a pilot in the United States controlling a drone thousands of miles away, had finally materialized. In doing so the attraction of 'push-button' war was reaffirmed and radicalised; its allure was less in its automated ease – killing as a modern convenience – than in the considerable distance it now opened up between pilot and target.<sup>74</sup> After President George W. Bush declared the inauguration of a 'global war on terror', he repeatedly explained to Americans that 'we fight them over there so we don't have to fight them over here'. The rapid generalization of remote operations beyond the manhunt for bin Laden promised the far more attractive prospect of fighting them *from* here.

### **Manhattan Projects 1.0 and 2.0**

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<sup>72</sup> Thomas Ehrhard, *Air Force UAVs: the secret history* (Arlington VA: Mitchell Institute for Airpower Studies, 2010) pp. 39-40; Lt. Gen. Gordon E. Fornell, USAF (Ret.), 'International Treaty Implications, Intermediate Nuclear Forces, and Strategic Arms Reduction Treaty,' UAV Technologies and Combat Operations, US Air Force Scientific Advisory Board Report SAB-TR-96-01, Vol. 2, November 1996, 7-17, 7-18; Whittle, *Predator*, pp. 171-183.

<sup>73</sup> Chris Woods, *Sudden justice: America's secret drone wars* (London: Hurst, 2015) pp. 23-27.

<sup>74</sup> Cf. Rachel Plotnick, 'Predicting push-button warfare: US print media and conflict from a distance, 1945-2010', *Media, culture and society* 34 (2012) 655-72.

Generalization took multiple forms in multiple theatres; the Predator and its later variant the Reaper were extensively deployed for intelligence, surveillance and reconnaissance, close air support and targeted killing in Afghanistan and Iraq, and for targeted killing outside these war zones in Pakistan, Somalia, Syria, Yemen and elsewhere. These counterinsurgency and counterterrorism operations all involved highly mobile targets, and in December 2004 the Defense Science Board argued that they would not be successful – that the ‘war on terror’ could not be won – without what it called ‘a Manhattan Project in scale, intensity and focus’ but ‘more intimate’ in temper to develop the capability for ‘tagging, tracking and locating’ these fleeting targets.<sup>75</sup> The appeal to the Manhattan Project was hyperbole, but it was also contagious. Next March a technical advisor in the National Security Agency’s Target Reconnaissance and Survey Division posed the following question and answer:

‘What resembles LITTLE BOY (one of the atomic bombs dropped on Japan in World War II) and as LITTLE BOY did, represents the dawn of a new era (at least in [signals intelligence] and precision location? If you answered a pod mounted on an Unmanned Aerial Vehicle (UAV) that is currently flying missions in support of the Global War on Terrorism you would be correct.’<sup>76</sup>

The language was excessive, even rebarbative, but it was not wholly without foundation. The programme devoted to identifying, locating, tracking and killing –

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<sup>75</sup> *Transition to and from Hostilities* (Defense Science Board, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, 2004) pp. xvi, 163, 170.

<sup>76</sup> Jeremy Scahill and Glenn Greenwald, ‘The NSA’s secret role in the US assassination program’, at <https://theintercept.com/2014/02/10/the-nsas-secret-role>, 9 February 2014. The pod was part of a system codenamed DISTANTFOCUS that intercepted and located cell phones. According to William Arkin, it involved ‘a set of black boxes’ – Airhandler, Gilgamesh, Pennantrace, Nebula and Windhammer – ‘all working together’ to analyse and fuse data: *Unmanned: drones, data and the illusion of perfect warfare* (New York: Little, Brown & Co., 2015) p. 187.

or on occasion capturing – individuals of special interest (‘High Value Targets’) has required a tremendous scalar transformation. It depends on the global interception of digital communications and the rapid analysis of big data by algorithms: a process described by some critics as ‘algorithmic war’.<sup>77</sup> This in turn depends on a computational apparatus whose origins can indeed be traced to the back door of the Manhattan Project.

Oppenheimer had always emphasised that the development of nuclear weapons was ‘singularly proof against any form of experimental approach’, so that in the initial stages it was far safer and cheaper to conduct paper rather than physical experiments. The design and construction of Little Boy and Fat Man had involved complex calculations, but these were done on comparatively simple machines or on electro-mechanical analogue computers that processed decks of punch cards. The development of the thermonuclear or H-bomb, ‘the Super’, posed a problem of a totally different order of magnitude and required a vastly more powerful computer. To validate the conjectures of the physicists and the designs of the engineers it had to be able to read coded sequences from high-speed memory and run exceptionally large numbers of numerical simulations. The first calculations for the ‘Super’ were run on the Electronic Numerator, Integrator, Analyser and Computer (ENIAC) at the Moore School of Electrical Engineering at Penn. This was an analogue computer but on a grand scale (it covered 18,000 square feet); digital technologies were still considered slow and unreliable and, as George Dyson explains, ‘analogue ruled the world’. ENIAC was completed too late to produce the ballistics tables for the US Army Ordinance Corps for which it had been built, and in December 1945 it was turned over to the calculations for Edward Teller’s ‘Super’. The run took six

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<sup>77</sup> Louise Amoore ‘Algorithmic war: Everyday geographies of the war on terror’, *Antipode* 41(1) (2009) 49–69; Lauren Wilcox, ‘Embodying algorithmic war: gender, race and the posthuman in drone warfare’, *Security dialogue* 48 (1) (2017) 11–28; Claudia Aradau, “The signature of security: Big Data, anticipation, surveillance,” *Radical Philosophy* 191 (2015) 21–28. Cf. the proud boast by Michael Hayden, a former Air Force General who served as Director of the CIA and the NSA under Obama, that ‘we kill people based on metadata.’

weeks and consumed one million punch cards, and while at first the results appeared to validate Teller's model it was subsequently discovered that they had been limited by the ENIAC's memory and were in fact seriously flawed. Progress stalled until Teller (with Stanislaw Ulam) proposed a modified design of the 'Super' in February 1951. But how could their design be confirmed? By then John von Neumann, a mathematician who had worked on the Manhattan Project and an ardent advocate of the Cold War – he was one of the models for Dr Strangelove – had successfully built an electronic digital computer at the Princeton Institute for Advanced Study. Oppenheimer was now the Director of the Institute, which had close if not uncontested links with the Atomic Energy Commission, and a team of scientists from Los Alamos collaborated with von Neumann to use his Mathematical Analyser, Numerical Integrator and Computer (MANIAC) for the requisite calculations. During the summer of 1951, camouflaged as an experiment in 'pure mathematics', MANIAC ran the single calculation non-stop for 60 days. The results proved the feasibility of the revised 'Super', and in November 1952 the first full-scale test of a thermonuclear device took place in the Marshall Islands. This was Ivy Mike, whose long-term consequences were immense. The same applied to MANIAC; by today's standards its memory was infinitesimal – just 5Kb – but its long-term effects were virtually incalculable. And the two were intimately related. Not only were 'the digital universe [through which the later modern drone would eventually fly] and the hydrogen bomb brought into being at the same time', as Dyson shows, but also their birth was part of the same military-scientific process.<sup>78</sup>

It was the analogue computer that drove Strategic Air Command's accelerated targeting cycle immediately after the Second World War. In 1946 SAC started to compile a computerised database of potential targets in the Soviet Union, which was

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<sup>78</sup> George Dyson, *Turing's Cathedral: the origins of the digital universe* (New York: Pantheon, 2012) p. 216; Paul Edwards, *The closed world: computers and the politics of discourse in Cold War America* (Cambridge MA: MIT Press, 1996); 'Computing and the Manhattan Project', Atomic Heritage Foundation, at <https://www.atomicheritage.org/history/computing-and-manhattan-project>, 18 July 2014.

soon extended to Soviet satellites and Korea. By 1960 the ‘Bombing Encyclopedia of the World’ contained 80,000 Consolidated Target Intelligence Files, which were harvested to plan nuclear strikes and calibrate damage and contamination models. One of the analysts responsible for nominating targets later described the process – and its dispersion of responsibility – as ‘the bureaucratisation of homicide’.<sup>79</sup> The same might be said of the procedures involved in preparing the ‘disposition matrix’ and the other kill lists that constitute the individualised target arrays for the current counterterrorism and counterinsurgency operations conducted by the CIA and the US military.<sup>80</sup> The computational basis is now completely different: thanks to the MANIAC, and like targeting cycles within US Strategic Command (the successor to SAC) and other combatant commands, advanced digital systems now drive contemporary decisions about targeted killing. They also guide their execution, which – in keeping with most other modalities of modern war – has also become a bureaucratic process, managed through screen-time rather than face-time.<sup>81</sup> The screens through which the strikes are orchestrated are mediations in an extended sequence in which the scattered actions and interactions of individuals are registered by digital intercepts and remote sensors, removed from the fleshiness of human bodies and reassembled as what Grégoire Chamayou terms ‘schematic bodies.’ They are given code names and index numbers, plotted on time-space grids and tracked on screens. Drones are closely involved in identification and geo-location – hence that pod underneath the Predator’s wings – and are almost always used in the

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<sup>79</sup> Outten Clinard, ‘Developments in air targeting: data handling techniques’, *Studies in Intelligence* 3 (2); Henry Nash, ‘The bureaucratization of homicide’, *Bulletin of the Atomic Scientists* 36 (40 (1980) 22-27. In the 1950s the analytical techniques used to compose the Bombing Encyclopedia were also used to calibrate the effects of nuclear strikes on targets within the United States: Stephen J. Collier and Andrew Lakoff, ‘The Bombing Encyclopedia of the World’, *Limn* 6 (2016).

<sup>80</sup> Jutta Weber, ‘Keep adding: on kill lists, drone warfare and the politics of databases’, *Environment & Planning D: Society and Space* 34 (1) (2016) 107-125.

<sup>81</sup> Richard Adams and Chris Barrie, ‘The bureaucratization of war’, *Ethics and Global Politics* 6 (2013) 245-60; Astrid Nordin and Dan Öberg, ‘Targeting the ontology of war’, *Millennium* 43 (2) (2015) 392-410; Peter Asaro, ‘The labor of surveillance and bureaucratized killing’, in Lisa Parks and Caren Kaplan (eds) *Life in the age of drone warfare* (Durham NC: Duke University Press, 2017) pp. 282-314.

tracking stage. Although air strikes can then be carried out by conventional aircraft, they are often also executed by drones (especially outside ‘areas of active hostilities’). As soon as the missiles are released the transformations that have produced the target over the preceding weeks and months cascade back into the human body: in an instant virtuality becomes corporeality and traces turn into remains.<sup>82</sup>

### Visual economies

All of this is mediated by screens, but the audience is screened too: the final awful moment in which the calculative is transformed back into the corporeal is made invisible to public scrutiny. The bodies of the dead and injured were also made to disappear from the images of Hiroshima and Nagasaki shown to publics in the United States, which were limited to the mushroom cloud and photographs of the devastated cities from the air. Unlike atomic bombs, however, aerial images are not secondary to or parasitic upon a drone strike; instead they are what Harun Farocki calls *operative* images that are an indispensable part of the operation and focal to its execution.<sup>83</sup> The strike videos released by the Pentagon typically show the multi-spectral targeting system tracking, centring a target in its crosshairs, and the missile streaking towards the ground. The climax is a displaced repetition of the video stream from the Hellcat drone cannoning towards North Korea: people who moments ago were tracking across the visual field in silent motion suddenly disappear, and the screen goes blank. This is not because the drone has plunged into the target – it hasn’t – but because otherwise the screen would be filled with dead and injured bodies. These ‘stand-off’ operations, as they are sometimes called, usually require the Predator or Reaper to remain on station to carry out a battle damage assessment that is often an inventory of body parts. But for public viewing these are ‘stand-off’ operations in quite another sense because the bodies killed and maimed in drone strikes are deliberately withheld from public audiences in the

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<sup>82</sup> Derek Gregory, ‘The territory of the screen’, *Mediatropes* 6 (2) (2016) 126-147.

<sup>83</sup> Harun Farocki, ‘Phantom images’, *Public* 29 (2004) 12-22: 17.

United States.<sup>84</sup> This is not out of a sense of decency, of what Farocki describes as a compulsion to spare the dead yet another humiliation, because these redacted videos are *also* operative images, designed to interpellate the viewer into what they make out to be bodiless wars, simultaneously virtual and virtuous.<sup>85</sup>

In contrast to all those American Hiroshimas, and other attempts to ‘bring home’ other wars, there have been few attempts to imagine a domestic drone strike, still less broken bodies on American ground. I can think of only three visual artworks that address military drones over the United States – George Barber’s ‘The Freestone Drone’, Omar Fast’s ‘5,000 Feet is the Best’, and Thomas van Houtryve’s ‘Blue Sky Days’ – and only Fast’s shows the aftermath of a strike (Figure 12).<sup>86</sup> Although drones patrol the southern and northern borders, apparently unarmed, and a number of police forces use them for surveillance, an enemy drone strike within the United States is extremely unlikely (though I realise that is not the point of any of these projects). One reason it is far-fetched is because the production and deployment of the Predator, the Reaper and similar platforms were at first confined

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<sup>84</sup> Similarly Eyal Weizman argues that satellite imagery used by investigators to reconstruct drone strikes is degraded to a resolution level incapable of registering a human body – which remains ‘hidden in the pixels’ – so that forensic visual analysis is forced to focus on buildings not bodies: *Forensic architecture: violence and the threshold of detectability* (New York: Zone Books, 2017) pp. 27-30.

<sup>85</sup> James Der Derian, *Virtuous war: mapping the military-industrial-media-entertainment network* (London: Routledge, 2009); cf. Derek Gregory, ‘Meatspace?’ at <https://geographicalimagination.com/2017/02/08/meatspace>, 8 February 2017.

<sup>86</sup> ‘5,000 Feet is the Best’ stages a reversal in which Chinese troops occupy the United States, and a missile is launched from a drone against three men planting an IED somewhere in California; it narrowly misses a white American family in their car. The manoeuvre brings into view the racialization of drone strikes: like Hiroshima and Nagasaki, most of those killed have been Asian. For commentaries on Fast, see Katherine Chandler, ‘5000 Feet is the Best: re-viewing the politics of unmanned aerial systems’; Matt Delmont, ‘Drone encounters: Noor Behram, Omar Fast and visual critiques of drone warfare’, *American Quarterly* 65 (2013) 193-202; Øyvind Vågnes, ‘Drone vision: towards a critique of the rhetoric of precision’, *Krisis* 1 (2017). I concentrate on visualizations because they are central to remote operations.

to the United States and a limited number of its allies.<sup>87</sup> Another is that they are relatively easy to shoot down, so that they can only be used in uncontested air space, against people or states unable (or in the case of Pakistan unwilling) to defend themselves. For these reasons, Chow's theses about the locations of bomber and bombed have more cogency in the age of drone warfare, where remote operations produce and prey on what Lisa Parks calls 'a new, disenfranchised class of "targeted" people' who live outside the United States, in borderlands where 'anyone and everyone is at risk and daily life is haunted by the specter of aerial bombardment.'<sup>88</sup>

Yet outside activist groups and human rights organizations, the disinterest in imagining drone strikes in the United States has not opened up a contrapuntal space in which the collateral victims in that distant 'elsewhere' have become visible. Although filmmakers and playwrights have dramatized US/UK drone strikes in Asia and Africa, they have almost always redirected the audience's gaze back to the United States or the United Kingdom – and in a startlingly new form. It is not those who are killed or injured in drone strikes who are portrayed as the central victims but those who carry them out: in the final, desperate instance it is their trauma that fills the screen or the stage. Andrew Niccol's *Good Kill* (2014) and Gavin Hood's

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<sup>87</sup> The future development of rival systems has provoked an anxiety comparable to fears of nuclear proliferation. 'We are in the same position now, with drones, that we were with nuclear weapons in 1945,' the editor of the *New Yorker* famously declared. 'For the moment we are the ones with this technology... But it's inevitable that other countries – including countries that are hardly American allies – will follow. Then what?': David Remnick, quoted in David Carr, 'Debating Drones, in the Open', *New York Times*, 10 February 2013. A similar train of thought prompted Richard Falk to explain 'Why drones are more dangerous than nuclear weapons', in Marjorie Cohn (ed) *Drones and targeted killing: legal, moral and geopolitical issues* (Northampton MA: Olive Branch Press, 2015) pp. 29-50. And in exactly the same way that the national security state has been haunted by the nightmare scenario of a terrorist with a 'dirty bomb', so there have been fears of terrorist groups adapting smaller-scale, commercial drones; Islamic State has now used commercial drones as aerial IEDs in Iraq and Syria.

<sup>88</sup> Lisa Parks, 'Grounded dimension of the US drone war in Pakistan', in Carolyn Marvin and Hong-sun Ha (eds) *Place, space and mediated communication: exploring contact collapse* (New York: Routledge, 2017) pp. 13-28: 22.

*Eye in the Sky* (2015) do not shrink from showing the carnage on the ground, but their dramatic force ultimately resides in the effects of targeted killing on its executioners. Both films raise serious questions about remote operations, but they invest little screen space in the lives of the innocents caught up in the strikes. The distance between ‘here’ and ‘there’ is at once contracted by the military gaze and expanded by the cinematic gaze, so that these become remote operations in an altogether different sense.<sup>89</sup> In George Brant’s play *Grounded* the split locations momentarily blur – a deeply troubled drone pilot transposes the arid landscapes of Nevada and Afghanistan, the face of her own daughter with the face of an Afghan child – but this is a solo performance in which the spotlight never moves far beyond her own anger and despair.<sup>90</sup> We have been here before, of course; it is the lives of people ‘like us’ that are made to matter, their trauma that is grievable, and the faces of others that are not *our* faces that are excluded from the frame.<sup>91</sup>

A rare exception is Sonia Kennebeck’s documentary *National Bird* (2016). The film opens with three former sensor operators whose memories of drone strikes still assail them. So far, so familiar. But then Kennebeck travels with one of them back to Afghanistan and stages a dramatic reconstruction of an air strike in February

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<sup>89</sup> I admire James Bridle’s Dronestagram project, which seeks to ‘bring home’ the locations of drone strikes by posting satellite imagery of their locations:

‘The political and practical possibilities of drone strikes are the consequence of invisible, distancing technologies, and a technologically disengaged media and society. Foreign wars and foreign bodies have always counted for less, but the technology that was supposed to bring us closer together is used to obscure and obfuscate.’

But because it is necessarily restricted to visual technologies close to those it seeks to undercut, its attempt is inevitably compromised: See ‘Dronestagram: the drone’s eye view’, <http://booktwo.org/notebook/dronestagram-drones-eye-view>, 8 November 2012.

<sup>90</sup> Christine Evans, ‘Drones, projections and ghosts’, *Theatre Journal* 67 (4) (2015) 663-86 makes the extremely powerful observation that these transpositions ensure that empathy emerges not through recognition but through *misrecognition* (p. 673).

<sup>91</sup> Cf. Judith Butler, *Prekarious life: the powers of mourning and violence* (London: Verso, 2004).

2010 in which the sensor operator was involved – directed by a drone crew from Creech Air Force Base in Nevada but carried out by two combat helicopters<sup>92</sup> – that killed more than twenty people and maimed many others, none of them combatants. Then, in truly remarkable sequences, Kennebeck incorporates amateur cell phone video and audio of the return of the bodies of the dead adults and children to their grief-stricken villages and follows the agonising attempts of the severely injured to come to terms with their now violently diminished, prosthetic lives.

### **Little Boys and Blue Skies**

Kennebeck’s artistry will not dispel the disregard of those who emphasise the differences between the biophysical effects of Hellfire missiles and nuclear weapons. But the issue is not as straightforward as it seems. When Harold Koh served as Legal Adviser to the State Department between 2009 and 2013, he often declared that he ‘would have preferred targeted killings to Hiroshima.’<sup>93</sup> Even so, this was a strange thing to say – nobody has ever suggested they are alternatives –

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<sup>92</sup> This has become the ‘signature strike’ cited in multiple critiques of drone strikes: see Derek Gregory, ‘Sweet target ... sweet child’ (forthcoming).

<sup>93</sup> Daniel Klaidman, *Kill or capture: the War on Terror and the soul of the Obama Presidency* (New York: Houghton Mifflin Harcourt, 2012) p. 203. In Afghanistan and other war zones targeted killing is also carried out by ground troops, especially Special Forces, but Koh’s legal interventions focused time and time again on the use of drones. For example:

‘[T]he real issue ... is not drone technology per se, but the need for transparent, agreed-upon domestic and international legal process and standards. It makes as little sense to attack drone technology as it does to attack the technology of such new weapons as spears, catapults, or guided missiles in their time. Cutting-edge technologies are often deployed for military purposes; whether or not that is lawful depends on whether they are deployed consistently with the laws of war, *jus ad bellum* and *jus in bello*. Because drone technology is highly precise, if properly controlled, it could be more lawful and more consistent with human rights and humanitarian law than the alternatives.’

See Conor Friedersdorf, ‘Harold Koh’s slippery, inadequate criticism of the drone war’, *The Atlantic*, 9 May 2013.

but it does important rhetorical work. Positing drone strikes and nuclear weapons as opposites distracts attention from the other forms of aerial violence that range between them, which remain as ever-possible modalities of later modern war, and obscures the affective landscapes they share with other forms of aerial violence.

Nuclear weapons and drones both target the social – only they do so in different ways. On 9 August 1945, the day Fat Man was dropped on Nagasaki, President Truman made a radio broadcast in which he told the American public that Hiroshima had been the target three days earlier because the United States ‘wished in this first attack to avoid, insofar as possible, the killing of civilians.’ It was a barefaced lie; there were military installations in the city, but Hiroshima had been selected because it was ‘the largest untouched target’, a city that had been spared from the firebombing campaign, so that its atomic destruction would be all the more spectacular. Both Hiroshima and Nagasaki were victims of a demonstration-effect.<sup>94</sup> The explosive blast alone would mark these as the most indiscriminate of weapons, but they not only kill and maim bodies in a lingering present – and in Hiroshima and Nagasaki most of them were almost certainly civilians – they also devastate the infrastructures, ecosystems and atmospheres on which the future conduct of social life depends.

The stakes in targeted killing are plainly much lower. The United States claims that outside established war zones its drone strikes are pre-emptive and it unilaterally extends the horizon of anticipation – sometimes extravagantly so – so that the danger need not be imminent to qualify as legitimate self-defence. In order to identify those who pose a threat within this landscape of deadly anticipation the population at large is transformed into an object of surveillance through which, so the United States insists, it becomes possible to parse combatants from civilians and to put ‘warheads on foreheads’ with unprecedented. In June 2011 John Brennan,

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<sup>94</sup> Ham, *Hiroshima*, p. 148. Truman had issued a public statement about Hiroshima on 6 August, in which he said that ‘the Japanese began the war from the air with Pearl Harbor’ and went on to emphasize the tremendous scientific advance involved in the development of the atomic bomb.

Obama's counterterrorism adviser, claimed that for almost a year the targeted killing programme had not caused 'a single collateral [civilian] death because of the exceptional proficiency, precision of the capabilities we've been able to develop'. Brennan's statement is not equivalent to Truman's outright lie, but it is deeply problematic all the same.<sup>95</sup> Drone strikes are directed against individuals or small groups, so fewer people are killed than in other forms of aerial violence – though one study found that in Afghanistan in 2010-2011 drones were ten times more likely to cause civilian casualties than conventional strike aircraft<sup>96</sup> – but in every case civilian status is conferred on – or withheld from – individuals by the assumptions and algorithms of the US military-intelligence apparatus. The categories of combatant and civilian are freighted with controversy, but there are good reasons to suppose that in practice the burden of recognition is increasingly being transferred from the combatant to the civilian, so that individuals under lethal surveillance are tacitly required to demonstrate their 'civilianness' to those watching them from afar. There have been situations, again in Afghanistan, when being an adolescent or adult male, travelling in a group, praying at one of the times prescribed by Islam, and carrying a firearm in a society where that is commonplace have been enough for civilians to be judged as hostile by drone crews and attacked: this checklist is in fact from the air strike dramatized in *National Bird*.<sup>97</sup> This is asymmetric war with a vengeance, in which people are made a part of the calculative apparatus of US counterterrorism but are not party to it. They are unwittingly cast as actors required to perform their civilian-ness in a play they haven't devised before an audience they

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<sup>95</sup> Chris Woods, 'US claims of "no civilian deaths" are untrue', Bureau of Investigative Journalism, 18 July 2011; Scott Shane, 'CIA is disputed on civilian toll in drone strikes', *New York Times*, 11 August 2011. Much of the criticism has centred on the CIA's accounting – who it counts as a civilian after a strike – but my concern is the larger question of how civilians are identified *before* a strike.

<sup>96</sup> Larry Lewis, Improving lethal action: learning and adapting in US counterterrorism operations

<sup>97</sup> Christiane Wilke, 'Seeing and unmaking civilians: visual technologies and contested professional visions', *Science, technology and human values* 42 (6) (2017) 1031-60; Gregory, "Sweet target". I borrow 'lethal surveillance' from Katharine Hall Kindervater, 'The emergence of lethal surveillance: watching and killing in the history of drone technology', *Security dialogue* 47 (2016) 223-238.

can't see – and which all too readily misunderstands the plot. They have no way of knowing if they are under surveillance, if their everyday activities are being misinterpreted, or if the people they encounter in perfectly innocuous ways have been identified as targets (so that they risk being found guilty by proximity). A journalist held captive by the Taliban in Pakistan's Federally Administered Tribal Areas reported:

'The drones were terrifying. From the ground, it is impossible to determine who or what they are tracking as they circle overhead. The buzz of a distant propeller is a constant reminder of imminent death.'<sup>98</sup>

As a result parents become afraid to send their children to school, relatives scared to attend funerals, families reluctant to entertain guests in their homes; even shopping or going out to work become activities fraught with fear. 'If I'm walking in the market ... standing on the road ... even in mosques, if we're praying, we're worried that maybe one person who is standing next to us is wanted.'<sup>99</sup> This is how drone strikes target the social: not by devastating infrastructures, ecosystems and atmospheres but by fraying the very fabric of social life so that, at the limit, society becomes atomised.<sup>100</sup>

This produces a doppelgänger landscape of deadly anticipation: just as the US military-intelligence apparatus scans the population to identify emergent threats, so in turn the people on the ground scan the skies for threats to their lives. This is a chronic feature across the spectrum of sustained aerial violence. The opening pages of Hersey's 'Hiroshima' were haunted by 'the premonition shared by the city's

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<sup>98</sup> *Living under drones: death, injury and trauma to civilians from US drone practices* (International Human Rights and Conflict Resolution Clinic, Stanford Law School/Global Justice Clinic, NYU School of Law, September 2012) p. 80.

<sup>99</sup> *Living under drones*, pp. 80-100: 98.

<sup>100</sup> Cf. Neal Curtis, 'The explication of the social: algorithms, drones and (counter)terror', *Journal of sociology* 52 (3) (2016) 522-36.

residents that an aerial attack was inevitable'. They could not have known what the United States had in store, but they were increasingly jittery. 'No matter what city the Americans planned to hit' during their firebombing campaign, Hersey recorded, 'the [B-29] Superfortresses streamed in over the coast near Hiroshima', and as time and time again the city was missed from 'Mr B's' hit-list so a rumour went around 'that the Americans were saving something special for the city.' Paul Saint-Amour has called this condition 'traumatic earliness'.<sup>101</sup> And in a later essay, he sutures the two together: 'Like nuclear weapons, drones turn the prospect of death from above into a condition of everyday life.'<sup>102</sup>

After a strike has happened the circles of violence contract and the attack becomes intensely personal. In his account of Hiroshima, Morrison noted that 'the great explosion had been for each survivor a bomb hitting directly on his house', and that sense of the particular in the midst of the general, individual disaster in the midst of collective catastrophe, haunts many survivors' narratives.<sup>103</sup> There is something irredeemably singular and solitary – profoundly, existentially personal – about the response to sudden, violent death from the sky. Families searching the rubble for the bodies of their dead are as alone in Dhatta Khel as they were in Hiroshima. Mark Bowden, no shrinking violet from the horrors of war, reaches the same conclusion:

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<sup>101</sup> Gerstle, 'John Hersey'; Hersey, 'Hiroshima'; Paul Saint-Amour, *Tense Future: Modernism, Total War, Encyclopedic Form* (New York: Oxford University Press, 2015) p. 1. Saint-Amour draws on Robert Lifton's description of the premonitory atmosphere in Hiroshima in the weeks before the bombing, an 'uneasy combination of continued good fortune and expectation of catastrophe': *Death in Life: Survivors of Hiroshima* (New York: Random House, 1968). Lifton subsequently treated the 'war on terror' as apocalyptic too, because 'it is militarized and yet amorphous, without limits of time or place, and has no clear end. It therefore enters the realm of the infinite': 'American Apocalypse', *Nation*, 4 December 2003.

<sup>102</sup> Paul K. Saint-Amour, 'Waiting for the bomb to drop', *New York Times*, 3 August 2015.

<sup>103</sup> Morrison, 'If the bomb', pp. 3-4.

‘Drone strikes are a far cry from the atomic vaporizing of whole cities, but the horror of war doesn’t seem to diminish when it is reduced in scale. If anything, the act of willfully pinpointing a human being and summarily executing him from afar distills war to a single ghastly act.’<sup>104</sup>

And so I turn, finally, to two survivors who give my essay its title. Yukiko Hayashi (her real name is Sachiko Kawamura), was just sixteen when the *Enola Gay* appeared over her city. Here is part of her poem, ‘Sky of Hiroshima’:

Daddy squats down, and digs with his hands  
Suddenly, his voice weak with exhaustion, he points  
I throw the hoe aside  
And dig at the spot with my hands  
The tiles have grown warm in the sun  
And we dig  
With a grim and quiet intent  
Oh...  
Mommy’s bone  
Oh...  
When I squeezed it  
White powder danced in the wind  
Mommy’s bone  
When I put it in my mouth  
Tasted lonely  
The unbearable sorrow  
Began to rise in my father and I  
Left alone  
Screaming, and picking up bones

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<sup>104</sup> Mark Bowden, ‘The killing machines’, *The Atlantic*, September 2013.

And putting them into the candy box  
Where they made a rustle  
My little brother was right beside my mommy  
Little more than a skeleton  
His insides, not burnt out completely  
Lay exposed... <sup>105</sup>

And here is young Zubair Rehman's heart-breaking admission after Hellfire missiles roared out of what he described as 'a very clear blue sky' on 24 October 2012 to kill his grandmother while she innocently gathered okra in the fields around her home in Ghundi Kala in North Waziristan. One year later he travelled with his father and his sister to Washington to testify before Congress about what had happened. 'I no longer love blue skies,' he told the handful of Congressmen who bothered to turn up to hear him. 'In fact, I now prefer grey skies. The drones do not fly when the skies are grey.' <sup>106</sup>

This is the Ground Zero where the past and present entanglements between drones and atomic bombs ultimately collide. There is nothing I can add to these two testimonies, except perhaps this: In the future I hope that 'little boys' will not be bombs – and that they will no longer be afraid of blue skies.

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<sup>105</sup> Yukiko Hayashi, 'Sky of Hiroshima', <http://www.hiro-tsuitokenkan.go.jp/taikenki/Esora.html>. Her father died of radiation sickness on 1 September 1945.

<sup>106</sup> Melinda Henneberger, 'From Pakistan, family comes to tell of drone strike's toll', *Washington Post*, 29 October 2013; see also Derek Gregory, 'Dirty dancing: drones and death in the borderlands', in Parks and Kaplan, *Life in the age of drone warfare*, pp.25-58.

