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The Provisional Irish Republican Army and the Development of Mortars

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Author Biography

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Abstract

The Provisional Irish Republican Army (PIRA) repeatedly showed itself to be one of the most inventive and adaptive of all the violent non-state actors who operated in the latter part of the twentieth century. Among its most innovative exploits was the PIRA's successful development and fielding – spanning almost its entire operational lifetime – of improvised mortar systems. This chapter will trace the sustained development of mortars, including the underlying motivations for pursuing mortars as a complex engineering effort, the process by which the development took place and the underpinnings of its success. The discussion will show that the PIRA's mortar development program was born out of tactical necessity but enabled by good organizational practices and the organization's access to materials, expertise and places in which to leverage these.

Disclaimer

Editor's Note: This article forms part of a series of related case studies collected in this Special Issue and should be viewed in the context of the broader phenomenon of complex engineering by violent non-state actors. Readers are advised to consult the introductory and concluding papers for a full explanation and comparative analysis of the cases.

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Introduction

The Provisional Irish Republican Army (PIRA)[1] was viewed by its allies and adversaries alike as one of the most inventive, innovative, and adaptive of all the violent non-state actors who operated in the latter part of the twentieth century.[2] During its almost three decades of attacks against civilians and security forces from 1969 until its last ceasefire in 1998, the PIRA employed a plethora of means of murder and mayhem, ranging from small arms (most notoriously the Armalite assault rifle), to rocket-propelled grenades, flamethrowers, heavier machine guns (such as the M60), and an almost dizzying array of improvised explosive and incendiary devices.[3] The focus here, however, will be on the PIRA's successful development and fielding–spanning almost its entire operational lifetime–of improvised mortars. **Error! Reference source not found.** shows the various generations of mortars that the PIRA developed, from its first highly hazardous and relatively ineffectual attempts in the early 1970s, to its massive 'barracks busters' of the 1990s. When it comes to judging the success of the PIRA's adoption efforts, it is apparent from **Error! Reference source not found.**that the PIRA, barely two years after its first tentative attempts,[4] succeeded in producing a reasonably reliable and safe weapon that at least some of the time resulted in physical damage and casualties, thus achieving a minimal level of success. Further, by the middle of the 1990s, PIRA mortars were evaluated as comparable in quality to military models.[5]

Most importantly for measuring success, the PIRA did launch several mortar attacks that caused serious injuries or fatalities and some that qualified as 'spectaculars'.[6] Among the more notable mortar attacks were:

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[1] For more general information on the PIRA, see Moloney, Ed, *A Secret History of the IRA* (New York, NY: W.W. Norton & Company Ltd., 2002), 46-71; also Coogan, Tim P., *The IRA* (New York, NY: Palgrave for St. Martin's Press, 2002); and English, Richard *Armed Struggle: The History of the IRA* (Oxford: Oxford University Press, 2003).
[2] Oppenheimer, A.R., *IRA: The Bombs and the Bullets, A History of Deadly Ingenuity* (Dublin: Irish Academic Press, 2009), 231.
[3] See Coogan, *The IRA*, 431-432; and Oppenheimer, *passim*, especially pp. 137, 170. Although never put into practice, the PIRA also reportedly worked on building fuel-air bombs, torpedoes, GPS-guided car bombs, and its own surface-to-air missiles (Oppenheimer, *IRA,* xviii, 9).
[4] The interval between the appearance of the Mark 1 mortar (1972) and the far more effective Mark 6 (1974).
[5] Geraghty, Tony, *The Irish War: The Hidden Conflict Between the IRA and British Intelligence* (Baltimore, MD: The Johns Hopkins University Press, 2000), 192.
[6] Although never causing nearly the scope of death and destruction as the so-called 'city buster' bombs in London and Manchester in the 1990s, the Downing Street and Heathrow mortar attacks were notorious more for the nature of the target than anything else.

1. *Newry Police Station* (February 28, 1985): The local unit and South Armagh volunteers launched nine Mark 10 mortar shells from a hijacked truck aimed at the RUC station in Corry Square, Newry. Eight shells overshot the station, but one landed on a canteen, killing 9 policemen and injuring 37 other people.[7]

2. *Downing Street Attacks* (February 7, 1991): During British Cabinet deliberations regarding the Gulf War, the PIRA fired three Mark 10 mortars from a specially-constructed opening in a van parked near Downing Street, central London. One mortar hit a tree and detonated several metres short of its target, shattering the blast windows in the Cabinet Room, forming a wide crater in the gardens and severely damaging Nos. 11 and 12 Downing Street. The other two shells did not explode and were rendered safe.[8] According to a law enforcement source familiar with the attack, the mortars were actually quite accurate–the only reason they missed the target was that the ranging mark on the pavement that the attack team had made the previous day had been washed away by snow, and the team had to estimate its position on the day of the attack, resulting in a few metres' discrepancy.[9] Had this intervention by Mother Nature not occurred, there might very well have been a direct hit on the Cabinet.

3. *Heathrow Airport Attacks* (March 8, 10 and 13, 1994): A PIRA team fired three separate salvos of 4-5 Mark 6 mortars at Heathrow Airport's northern runway and Terminal Four building. One bomb landed on the roof of Terminal Four, which had approximately 4,000 occupants at the time. None of the mortars exploded, perhaps because the PIRA had not intended them to, but one widely-held opinion is that they had been sabotaged by security forces or an informer.[10] Nonetheless, the targeting of a facility in which a successful attack could have caused thousands of civilian casualties represented one of the most ambitious attacks by the PIRA up to this time and the fact

[7] One of the former law enforcement officials remarked to the author that, although the accuracy was reasonable, the attack was not quite as successful as often reported, since only one of the eight mortars detonated. Author interview with former Northern Ireland law enforcement official 'C'.
[8] Oppenheimer, Andy, *30 Years of IEDs: The Operational Art of the Provisional IRA*, PIRA–Lessons Learned Conference (Stockholm: Swedish National Defence College, 17 April 2012).
[9] Author interview with former Northern Ireland law enforcement official 'B'.
[10] Moloney, *A Secret History of the IRA*, 424.

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> that a second and third attack were possible despite increased security caused embarrassment for authorities.[11]

Irrespective of casualties, all of these attacks had substantial psychological impact (the *raison d'être* of genuine terrorism). This, together with the casualties that were caused and the drastic improvements in the weapons themselves, lends weight to a conclusion that, as a whole, the PIRA successfully adopted the weapons technology of mortar systems. The important questions are why and how they did this.

Decision

Evidence points towards the PIRA's decision to develop mortars as being driven by the perceived need to address a specific tactical performance requirement. The Provisionals were confronted by a new challenge when many of its prime targets in Northern Ireland, police stations and barracks, began to be heavily fortified in the early 1970s.[12] Initial attempts to circumvent these defences consisted of catapulting petrol bombs from nearby roofs and subsequently what is referred to as a 'spigot grenade',[13] a container of explosive with a lit fuse attached to the end of a dowel rod, which was fired from a bow or shotgun. Needless to say, both of these approaches left a lot to be desired in terms of safety and reliability and alternatives were sought.[14] To anyone familiar with weapons at the time, mortars were a logical choice in order to overcome the physical hardening occurring around the PIRA's favoured target facilities, such as police stations, which usually consisted of stronger perimeter fortifications but left the roofs of the facilities relatively unprotected. In other words, the PIRA were driven to seek mortars by a tactical need.[15] Other tactical advantages of mortars included: a) providing a standoff capability that would help shield their operators from detection;[16] and b) the high ballistic arc of a mortar made it possible to fire on targets fairly close to the launcher (at least when measured relative to other forms of

[11] Oppenheimer, *IRA*, 232. The mortars had been concealed underground and were fired from an area close to the perimeter fence.
[12] Oppenheimer, *IRA,* 229.
[13] Ibid., 228-229.
[14] Ibid., 229.
[15] Author interview with former Northern Ireland law enforcement official 'A'. This was yet another example of where, 'Above all, necessity–and the constant need to improvise, usually in covert and haphazard conditions–was the mother of IRA invention' (Oppenheimer, *IRA,* xx).
[16] Personal correspondence with Dr. Brian Jackson, RAND, 16 May 2012.

artillery)–or even above it–which at times could be useful in built-up urban environments.[17]

The security countermeasures installed by the British could conceivably have been dealt with in other ways, such as shifting to different targets, infiltrating facilities, building bigger bombs or finding simpler methods of getting bombs over the walls. Upon closer inspection, however, none of these alternatives were really open to the PIRA of the early 1970s. Target shifting was not an attractive option–the Provisionals were already trying to bring commercial activity in Northern Ireland to a standstill through bombing city centres in towns like Derry and Belfast and, at least in Northern Ireland, the PIRA did not want to be seen to intentionally target civilians.[18] Allowing the other focus of their operations—British and Northern Ireland security forces–to retreat to the safety of their bases was not a viable option under the PIRA's strategy of the time. Furthermore, while their bomb-making was becoming more proficient and they were embarking on the production of home-made explosives, the days of the 'city destroyer' bombs of the 1990s were far off and it is doubtful whether the organization could have developed explosive devices big enough–and stationed them close enough–to blast their way through the fortifications. Last, simpler methods had failed to show much promise: flare bombs were insufficient to cause much damage, the spigot grenades were too dangerous, and hijacking aircraft to drop bombs on the roofs of police stations was impractical on a large scale.[19]

With respect to the decision makers and the decision process, much of this stemmed from the PIRA's organizational structure. Organizationally, the PIRA was something of a hybrid. On the one hand, at the time of its split with the Official IRA in 1969, the PIRA theoretically inherited the well-defined, traditional structure of Irish Republican militants, which was modelled somewhat ironically on the British Army.[20] Under this structure, supreme authority on a daily basis rested in the Army Council, which directed a General Headquarters (GHQ) consisting of ten specialist departments. On the other hand, in practice, while overall strategy was laid out by the Army Council, operational control was far more decentralized. Local units enjoyed a high degree of autonomy in such factors as targeting and weapons

[17] See Oppenheimer, *IRA*, 228 for a similar idea.
[18] Jackson, Brian A. et al, *Aptitude for Destruction-Vol. 2: Case Studies of Organizational Learning in Five Terrorist Groups* (Santa Monica, CA: RAND, 2007), 212.
[19] O'Doherty recounts an episode when he volunteered to go up in a helicopter to investigate whether it would be possible for explosives to be dropped on Strabane police station (author interview with Shane Paul O'Doherty).
[20] English, *Armed Struggle,* 114; and Coogan, *The IRA,* 379.

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employment.[21] Therefore, the PIRA exhibited both top-down and bottom-up decision-making.[22]

Yet, for a decision of the magnitude of whether or not to embark on a major enterprise like the acquisition or development of mortars, decision making likely took place at the center of the organization.[23] In fact, O'Doherty specifically mentions the development of mortars as one of the few decisions that was centralized during his tenure with the organization in the early 1970s.[24] It is therefore extremely probable that the final decision regarding whether or not to acquire mortars, and whether to embark on an indigenous development program, would have rested with the Army Council. It is quite unlikely, however, that the Army Council would make a decision to adopt mortars without some input from below. The most probable sources of such input would be the department of the Quartermaster General (QMG) and the Engineering Department. While the QMG would presumably have a greater say in the case of externally acquired mortar systems and the Engineering Department would predominate in discussions of internally developed mortars, both departments would likely be heavily involved in providing guidance and expert opinion to the Army Council (especially since the QMG usually sat on the Army Council itself).

This somewhat bidirectional nature of decision making within the PIRA has been confirmed by a former law enforcement official familiar with PIRA command and control as being the most probable operationalization of the mortar adoption decision. In this dynamic, bottom-up requirements and suggestions would filter up through the hierarchy to the Army Council from local units, and technical assessments of the feasibility of the endeavour would be given by those with expertise in GHQ (especially the Quartermaster and Engineering Departments).[25] The Army Council would then make the final decision in a top-down fashion and implement it through the Chief of Staff and GHQ.[26] Richard English has singled out the PIRA's somewhat flexible command and decision making structure–the "combination of high-

[21] John Horgan and Max Taylor, "The Provisional Irish Republican Army: Command and Functional Structure," *Terrorism and Political Violence* 9:3 (1997): 23; Dillon, Martin, *The Dirty War* (New York, NY: Routledge, 1990), 153; Toolis, Kevin, *Rebel Hearts: Journeys Within the IRA's Soul* (New York, NY: St. Martin's Press, 1995), 319.
[22] Author interview with former Northern Ireland law enforcement official 'A'.
[23] Author interview with former Northern Ireland law enforcement official 'D', Belfast, Northern Ireland, 19 June 2012.
[24] Author interview with Shane Paul O'Doherty.
[25] Author interview with former Northern Ireland law enforcement official 'A'.
[26] Author interview with former Northern Ireland law enforcement officials 'A' and 'D'.

level centralization with locally autonomous initiative"–as playing an important role in the PIRA's constant efforts to innovate.[27]

How did the decision to develop mortars relate to the PIRA's overall tolerance for risk? The PIRA at its inception was ready to engage in a variety of different combat modes. The action orientation of young, 'fired up' recruits made them quite willing to engage British and RUC (Royal Ulster Constabulary) forces at close range in the streets.[28] They were also willing to experiment with explosives (with several cases that brought tragic results[29]). Although the PIRA did calibrate its violence from time to time for political or strategic reasons, it engaged in fairly risky behavior throughout its lifespan (e.g., importing arms from Libya, using unwilling "human bombs", and trying to attack both Margaret Thatcher and the British Prime Minister's residence directly).

With respect to its overall planning horizon, even after the initial decision to engage in the production of mortars and the production of the first relatively successful variants, the PIRA persisted in further phases of mortar development. It even substantially expanded the breadth of its R&D program. For example, there were another eleven models after the Mark 6, which was sufficiently reliable to be utilized in the high-profile 1994 attack on Heathrow Airport twenty years after it was first deployed. The mortar program thus represented an ongoing, long-term development effort, which consisted of constantly attempting to increase the mortars' effectiveness as weapons and decrease the risk posed to their handlers. This long-term thinking was most cogently expressed in reports of the PIRA encouraging promising future technicians to remain in school in order to increase their technical knowledge, as in the case of Danny McNamee, who became a leading bomb-maker and was supported in his technical studies at Queen's University, Belfast, by the PIRA.[30]

Part of the reason for the length of the effort may have been that a degree of momentum arose, similar to that which develops behind many long-term development programs that are at least partially insulated from interference by the leadership or enemy forces. Members of the mortar development

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[27] English, Richard, *Armed Struggle: The History of the IRA:* (Oxford: Oxford University Press, 2003), 119.
[28] Shane Paul O'Doherty, *The Volunteer: A Former IRA Man's True Story,* (Durham, CT: Strategic Books Group, 2011), 60-61; Jackson et. al., "Provisional Irish Republican Army" in *Aptitude for Destruction*, 100.
[29] See, for example, Coogan, *The IRA*, 367.
[30] Oppenheimer, *IRA,* 275-276.

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team, revelling in their technical prowess, may have been loath to cease working on a challenging system that attracted a large amount of external attention to the movement. However, there were doubtless external, in addition to organizational, drivers of continued development. Offense and defence in general establish a co-evolutionary dynamic that, from the PIRA's point of view, forced its 'mortar offense' to constantly adapt and grow in order to cope with more robust defences, or in Oppenheimer's words, "to keep the authorities on the hop".[31] Larger, more penetrating mortars were required, for instance, by further British hardening of military structures specifically against mortars in the 1980s, including an empty top floor and a reinforced roof of their bases.[32] Desensitization[33] of the media, the British enemy, and even the group's constituencies after multiple uses of the same weapon–some mortars were used hundreds of times–might also have driven the leadership to demand something new and extend the development program.

Implementation

The PIRA almost exclusively cultivated its mortars 'in-house', with the vast majority of components and production occurring within the organization. This was conducted mainly through its own institutional R&D organ, the Engineering Department (ED) of the Army General Headquarters, with some participation from certain highly dynamic local units, especially the South Armagh Brigade. There was also some exploitation of existing commercial networks in the use of widely available legitimate products as the basic raw materials for mortars.

It is also unclear exactly where the expertise required for developing mortars was acquired. It is known that the PIRA drew on many talented amateurs (such as the Derry volunteers Shane Paul O'Doherty in the seventies and Patrick Flood in the eighties) who rapidly became proficient in their bomb-making craft and were able to improvise extensively. It is also known that the PIRA attracted a limited number of highly-skilled technical personnel, including professional engineers.[34] With respect to weapons-specific

[31] Ibid., 292.
[32] Urban, Mark, *Big Boys' Rules: The Secret Struggle Against the IRA* (London: Faber & Faber, 1992), 207; Geraghty, Tony, *The Irish War: The Hidden Conflict Between the IRA and British Intelligence* (Baltimore, MD: The Johns Hopkins University Press, 2000), 94.
[33] Alex P. Schmid and Janny de Graaf, *Violence as Communication: Insurgent Terrorism and the Western News Media* (Beverly Hills, CA: Sage Publications, 1982), 172.
[34] In the 1980s, for example, the organization began to attract even more highly-specialized individuals, such as Richard Johnson and Eamon McGuire, who had backgrounds in electrical and aeronautical engineering (McGuire, Eamon, *Enemy of the*

knowledge, there is evidence of early PIRA access to military manuals of various armed forces,[35] certain members with military experience, at least some training by Libya,[36] and even indications of transfer of military knowledge from Russia and Germany during the first half of the 20th century.[37] It is thus likely that the expertise was derived from a kernel of inherited knowledge that was built upon by trial-and-error, a hypothesis borne out by the intense experimentation evident during the early period of mortar development. As to the identity of the developers, directors of the Engineering Department, like Frank McGuiness[38] and Gabriel Cleary,[39] probably had at least some involvement in the R&D process for mortars, while some of those individuals most closely associated with mortar development include Bernard Fox, Ciarain Chambers, and James 'Mortar' Monaghan.[40] It has also been revealed that for most of the period of development, the PIRA stuck with more-or-less the same full-time R&D team, as evidenced by the discovery of signature welding marks and initiation devices that were consistent across various mortars.[41]

Interestingly, the mortars' designers might not have even conceived of their work as a structured development process at all, rather focusing on the next project as merely an exercise in providing a weapon that met the specifications that the operational personnel desired. However, more decentralized local operatives were occasionally brought in to consult or to help with testing.[42]

With respect to safety, while the organization as a whole did not want its members harmed in the course of their duties, safety did not always seem to be a high priority, especially in the early years. Many of the explosives used were volatile and the designers did not include safety mechanisms in at least

Empire: Life as an International Undercover IRA Activist (Dublin: O'Brien Books, 2006)).

[35] Oppenheimer, *IRA,* 242; author interview with Shane Paul O'Doherty, Athlone, Republic of Ireland, 20 June 2012.

[36] Patrick Magee, one of the PIRA's best-known bomb makers, allegedly went to Libya for training in the 1970s (Oppenheimer*, IRA*, 263, 282; author interview with Shane Paul O'Doherty).

[37] Author interview with former Northern Ireland law enforcement official 'C', Belfast, Northern Ireland, 19 June 2012.

[38] Moloney*, A Secret History of the IRA*, 439.

[39] O'Callaghan, Sean, *The Informer* (London: Corgi Books, 1999), 305.

[40] Author interview with former Northern Ireland law enforcement official 'C'; Horgan and Taylor, "Provisional Irish Republican Army", 14; Oppenheimer, *IRA*, 99, 281.

[41] Author interview with former Northern Ireland law enforcement official 'A', Belfast, Northern Ireland, 18 June 2012 and author interview with former Northern Ireland law enforcement official 'B', Belfast, Northern Ireland, 18 June 2012.

[42] Author interview with Shane Paul O'Doherty.

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the first five variants, resulting in 'own goals', such as the death of two PIRA volunteers from the premature explosion of a Mark 3 mortar in 1973.[43] However, much of the impetus for continuing to develop mortars after the fairly successful Mark 6 was to improve safety. With respect to operational security, the PIRA, for much of its operational lifespan, enjoyed some degree of succor from supporters in rural areas of the Republic of Ireland and faced Irish authorities that were not really equipped to pursue them, thus providing the organization with a form of safe haven in the South. Thus, operational security in these areas was less of an issue. However, in Northern Ireland and England, they were under increasing security pressure, including infiltrators, informers, and surveillance by a variety of British security forces (including the British Army, the RUC and the Special Branch).[44] This made security an increasing priority and was one of the main reasons that most of the mortar development had to take place in the Irish Republic.

Turning to the process by which the mortars were produced, **Error! Reference source not found.** provides a detailed chronological account of the PIRA development of mortars. There are, however, a few key points about the production process in general that are not included in the table. First, there is some uncertainty as to where the actual development of mortars took place and whether this development was at a single or multiple locations. One opinion is that the PIRA had a single 'factory' responsible for producing mortars, but that the location of this factory changed from time to time.[45] Reports of Irish police raids in the early 1970s, however, suggest that there were different locations for different components, including a factory in Dublin (discovered in 1975) that fabricated firing tubes and a light engineering works in County Cavan (uncovered in 1976) where the mortar shell casings were being manufactured.[46] There are also reports that place South Armagh as a hub of mortar building and testing activity in the 1970s.[47] In 1988, the PIRA allegedly established a mortar bomb factory in Belfast itself, in the Andersonstown area,[48] and Tony Geraghty reports that in December of the same year, the discovery of a PIRA bomb 'factory' in South London revealed items associated with the manufacture of the Mark 10

[43] O'Callaghan, *The Informer,* 84-85. This to some extent paralleled the wider safety issues that the PIRA was having at the time when it came to dealing with explosives. For example, in June 1970 much of Derry's PIRA leadership (together with two children) were killed while constructing bombs in a kitchen (Toolis, *Rebel Hearts*, 304).
[44] Dillon, Martin, *The Dirty War* (New York, NY: Routledge, 1990).
[45] Author interview with former Northern Ireland law enforcement official 'C'.
[46] Oppenheimer, *IRA*, 170.
[47] Harnden, Toby, *Bandit Country: The IRA and South Armagh* (London: Coronet Books, 2000), 233.
[48] Dillon, *The Dirty War,* 292.

mortar, indicating that some mortar production might even have been occurring outside of Ireland.[49] One might speculate that during the initial period, mortar development took place mainly in the Republic of Ireland (and some Republican strongholds like South Armagh), but that as the PIRA's production capabilities matured and the number of mortars sought increased, production locations multiplied and became more local to their places of intended use.

Second, with respect to the explosive components of the mortars, explosives used as the main charge in mortars could generally be sourced from almost the entire range of the PIRA's prodigious arsenal of explosives types,[50] although lighter charges, and hence more powerful 'high' explosives, were probably preferred in most mortars to meet the exigencies of aerodynamics. This was made easier after the PIRA received large quantities of Semtex high explosive from Libya in the mid-1980s. Trigger, timing, and power units for the mortar systems could similarly be drawn from the extensive broader PIRA inventories and expertise in these areas.[51] The propellant used to launch the mortar was a different matter entirely. This had to be carefully formulated to achieve a safe and reliable launch, imparting a relatively steady explosive force to the mortar shell in order to ensure a consistent range. **Error! Reference source not found.** traces the evolution of propellants, from early reliance on commercially available shotgun and related powder cartridges, through the J-cloth,[52] to the more sophisticated purpose-built and precisely measured propellants that formed part of the weapon itself.

Third, construction of the non-explosive components of the mortar showed just as much ingenuity. Early seizures of mortars, like that in 1974, informed the security forces that components such as the housing were being manufactured in a facility containing at least a metal lathe and heavy welding equipment, akin to a light engineering workshop.[53] The aforementioned raids of PIRA mortar production facilities in 1974 and 1975 indicated an incipient

[49] Geraghty, Tony, *The Irish War: The Hidden Conflict Between the IRA and British Intelligence* (Baltimore, MD: The Johns Hopkins University Press, 2000), 192.
[50] When supplies of commercial explosives like gelignite became scarce during the first phase of mortar development, specialist units in the PIRA focused on the manufacture of home-made explosives and developed multiple recipes, mostly based on various compounds containing ammonium nitrate fertilizer. See, among others, Jackson, *Aptitude for Destruction*, 99; and O'Callaghan, *The Informer,* 89.
[51] For an extensive discussion, see Oppenheimer, "Chapter X," in *IRA*.
[52] This propellant was apparently made by soaking an absorbent cleaning cloth – typically of the "J-Cloth" brand – in a sodium chlorate solution. See Geraghty, *The Irish War*, 189.
[53] Ibid., 170.

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light industrial capacity,[54] which undoubtedly grew as the larger mortar models were developed to the point where Oppenheimer characterizes this capability as having a production line quality.[55] Many of the raw materials for mortar components were sourced from commercially available pipes and gas cylinders, thus minimizing the amount of machine tooling required.

The path to developing a robust mortar capability did not proceed without incident, however. The PIRA experienced several difficulties and setbacks, which can also be gleaned from a close look at **Error! Reference source not found.**. The accuracy of many of the models was poor, not only of the earlier attempts, but sometimes (as with the Marks 7, 8, and 9) accuracy was knowingly traded for greater explosive power. Another major problem was the safety of the initial devices, as mentioned above. Compounding safety and accuracy issues was a lack of detonation reliability–many of the mortars, even if they did not blow up on launch or hit the wrong target, failed to detonate upon impacting the intended target. Nonetheless, the PIRA's technicians persevered with the development of mortars and were eventually successful in addressing many of the problems of safety and reliability through a number of ingenious advances, from impeller-operated arming mechanisms to sophisticated timers and triggers. Although accuracy presented a perennial problem, even this improved markedly. For example, according to a former Northern Ireland law enforcement official, in the 1985 attack on the Newry Police Station, the landing locations of the several mortars used were closely grouped, indicating a fair amount of accuracy and reliability in ballistic trajectory.[56] These achievements were all the more remarkable when one considers that over the entire period of development, the PIRA was under intense security pressures.

Analysis

The basic tactical need underlying the decision to adopt mortars has been detailed above. Yet, the key question in this regard is why the PIRA decided to produce this capability themselves, rather than, for example, procuring mortars on international arms markets. Reasons for taking on this complex engineering task include the following:

- *Difficulties Associated with External Acquisition:* The PIRA sourced many of its weapons through patronage (primarily through the

[54] Ibid.
[55] Author interview with Andy Oppenheimer, London, England, 22 June 2012.
[56] Author interview with former Northern Ireland law enforcement official 'B'.

largesse of Libya's Moammar Gaddafi and Irish-American sympathizers in the United States)[57] and exploitation (such as purchasing arms from third party suppliers or stealing detonators from commercial quarries), but these sources presented certain disadvantages for more sophisticated weapons like mortars. First of all, the basic purchase of weapons systems on the open market can be expensive, and can open the organization's activities up to interdiction or infiltration by security forces which can simply monitor known arms suppliers, not to mention the additional resource costs and risks associated with transporting, storing and maintaining purchased arms.[58] While the IRA had a steady funding stream for most of its existence, especially in the early years this funding was limited. Moreover, several of the organization's attempts to import arms, whether from purchases or overseas patrons, were interdicted in the 1970s and 1980s, with notable examples being seizures of weapons at Schipol Airport (1971) and on the ships, the *Claudia* (1973), the *Marita Ann* (1984) and the *Eksund* (1987).[59] Some reports list mortars among the seized weapons,[60] but it can be inferred that, while the organization's officers might have attempted to include externally-sourced mortars in large arms consignments at various times, these attempts were not successful, since this type of mortar was never used by the PIRA. Furthermore, a former law enforcement official has stated that the PIRA never procured commercially available mortars.[61] Possessing an internal production capability would obviate many of these risks, because large numbers of mortars did not need to be stored, but could be manufactured as needed. Also, any interdictions of mortars would not negate the knowledge of how to build new ones in the future,[62] and necessary components could be purchased legitimately – and more cheaply – than military mortars.[63]

- *Specific Tactical Requirements:* The PIRA had usage requirements that differed substantially from military mortars. While military mortars were designed for fairly long ranges (~5,000m), to have the

[57] Moloney, *A Secret History of the IRA*, 8-12; Dillon, Dirty Wars, 396.
[58] Oppenheimer, IRA, 150.
[59] Coogan, *The IRA*, 432; Keith Craig and Ian Geldard, *IRA, INLA: Foreign Support and International Connections* (Institute for the Study of Terrorism, 1988); Toolis, Rebel Hearts, 67; Maloney, 3-8.
[60] Ibid., 171 and Dillon, Dirty Wars, 399, for example, mention mortars amongst the weapons seized by Belgian customs officers in 1977.
[61] Author interview with former Northern Ireland law enforcement official 'B'.
[62] Personal correspondence with Dr. Brian Jackson.
[63] Oppenheimer, IRA, 150.

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firer present upon launch and to be used numerous times, the nature of the PIRA's covert terrorist campaign meant that it required mortars operative over shorter ranges (within the confines of a city), with options to fire remotely and where the launcher was generally abandoned after a single use.[64] Moreover, military mortars required expertise and practice to aim correctly and achieve desired accuracy; the PIRA volunteers launching mortars from the back of a van and aiming in the general direction of a police station were operating under different functional constraints.[65] Producing its own mortars would thus allow the PIRA to customize weapons for its own purposes.

- *Deficit of Trust in Externally Sourced Materials:* As the conflict in Northern Ireland wore on, there were increasing cases of British or RUC counterintelligence personnel 'doctoring' or otherwise sabotaging PIRA weapons–including guns with built-in surveillance devices or explosives that would not detonate.[66] This led to PIRA engineers having decreased confidence in externally-sourced materiel and provided an additional impetus to produce those weapons internally when it could.

- *DIY Prestige:* In addition to the purely tactical advantages of particular weapons, there were also the symbolic messages that would be tacitly conveyed by the use of a particularly sophisticated weapon. It is reported that at all levels of the PIRA, from the organization as a whole to individual units, there was often the desire to show various audiences, whether it was the British, its Catholic constituency, or even other brigades in the PIRA, how ingenious, capable, and terrifying the PIRA could be–an indigenous mortar capability would thus bestow propaganda benefits on its developers.[67]

- *Technical Confidence and Constituencies*: The PIRA possessed one of the most mature, highly-skilled, and productive research and development organs in the annals of violent non-state organizations, the so-called Engineering Department. The ED's committed and cunning senior technicians were responsible for numerous breakthroughs in the arts and instruments of clandestine war against the state and enjoyed a substantial level of influence as the PIRA's

[64] Author interview with former Northern Ireland law enforcement official 'A'.
[65] Ibid.
[66] See Dillon, *The Dirty War,* 229 for examples.
[67] Oppenheimer, IRA, 257.

elite.[68] Their early successes with explosives mixtures in the 1970s (following some initial missteps in this regard) might have given them (and the PIRA's senior command) the confidence that they could take on the difficult task of developing an effective mortar capability. Even if this confidence had been lacking among members of the Army Council or other senior leadership, the ED enjoyed a degree of independence from frontline operations,[69] and the decision to engage in the development and production of mortars may have been the PIRA leadership's way of "letting the movement's better technical intellects have their experiments".[70] The subsequent history of the organization certainly presents many examples of highly educated and skilled individuals being given more or less free rein to develop or acquire new weapons technologies.[71]

- *Weapon Evolution*: Indigenous development allowed for the PIRA's mortar capability to evolve over time, and adapt to new requirements and developments, whereas if mortars were externally sourced, a new product would have to be identified, possibly necessitating the development of a relationship with a different supplier and the locating of new transport channels.

There were thus several synergistic factors pushing the PIRA in the direction of putting the time, resources, and effort into developing their own mortar systems. While indigenous production might have been overdetermined, and it is difficult to say whether any single one of these factors would have been sufficient to encourage the organization to move in this direction, the specific tactical requirements and lack of trust in external sources of weapons both provided strong incentives to develop mortars internally.

We can now turn to examine the key determinants of the PIRA's success in this regard. After a thorough analysis of the context surrounding the PIRA's development of mortars, three interrelated factors stand out as most salient. The first factor stems from the PIRA's organizational and individual expertise and access to required materials. The PIRA inherited a lot of latent

[68] Horgan and Taylor, *Provisional Irish Republican Army,* 14.
[69] Oppenheimer, *IRA*, 280.
[70] Urban, *Big Boys' Rules,* 210.
[71] One of the more well-known examples is that of the so-called 'Boston Three' (actually five scientists, including an aeronautical engineer, a computer scientist and someone with high-level U.S. security clearance) who set about developing a guided missile system in the United States with the aim of being able to shoot down British aircraft (primarily helicopters) in Northern Ireland – see McGuire, *Enemy of the Empire,* 211-212; 25.

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knowledge from before the 1969 split, which meant that the organization did not have to start from scratch, so to speak, either technically or organizationally and, although it was strapped for weapons and other resources in 1970, it was able to build on its legacy capabilities to quickly reconstitute its expertise and access to resources. In addition, the socio-economic background of its membership ended up serving it well in the area of weapons development. The majority of its members were working-class Catholics, who while not necessarily possessing the technical skills for weapons development, brought with them a basic inventiveness, creativity, and 'working men's skillsets' like machining and welding. In addition to the direct value of such experience in the fabrication of mortars, this background quickly allowed the organization to develop a high level of practical skill–something that was essential for solving the obstacles encountered in developing improvised weapons. At the same time, the appeal of the PIRA was sufficiently broad that the organization was able to attract the services of a small number of highly-trained individuals, including engineers, chemists, and computer scientists to provide the requisite knowledge of aerodynamics, timing systems, and so forth. There was also an organizational structure that was set up to promote and implement innovation from the very beginning. The embodiment of this institutionalization of R&D, the Engineering Department was somewhat isolated and protected from frontline operations, which allowed for the possibility of long-term R&D projects like mortars. At the same time, the organization also made room for local EOs (explosives officers) in the various towns in the North to react to local conditions and independently engage in local-level innovation, which could then filter back to the center.[72]

The second major contributor to success was its access to safe havens. The existence of a large area in the Republic of Ireland in which to conduct research, production, and testing that was beyond the reach of British authorities has been identified as a key element in the success of the PIRA's mortar program.[73]

Last was the PIRA's culture of learning. In the area of weapons development, the PIRA displayed an aptitude for learning that is unrivalled among terrorist groups. The first form of learning it engaged in was pre-employment testing of weapons systems. O'Callaghan describes firing mortars with dummy shells

[72] For instance, Shane Paul O'Doherty–at the time the local Derry EO–who had a reputation for inventiveness was asked to come down South to consult with engineers who were developing the early mortars. Author interview with Shane Paul O'Doherty.
[73] Author interview with former Northern Ireland law enforcement official 'A'.

at Inch Strand on the inner side of the Dingle Peninsula, where the shells would land undamaged on the sandy beach,[74] while O'Doherty describes visiting a farm in Kildare in 1972 where mortars were tested for range and weight-bearing capability.[75] The second aspect of the culture of learning was the willingness and institutionalization of post-operation analysis. When things went wrong with an attack, the operatives conducting the attack would be debriefed by superiors. Of course, 'own goals' (where the PIRA operatives were themselves killed) made it very difficult to identify the source of the failure.[76] After-action reporting did not only occur when missions went awry–this practice was so pervasive that it has been described as 'debrief–win, lose or draw'.[77] While the PIRA was unable to perform technical analyses of successful attacks or even observable failures (since the mortars or their remnants would be within the control of the authorities), they did the next best thing, by sending observers to stand at police cordons and try to gather as much information about the effects of the attack or the unexploded ordinance as possible.[78] This commitment to constant learning and improvement was a powerful enabler of the rapid development and success of the mortar program.

The sustained development of mortars, which included all system components, from the casing and the propellant to the warhead and the trigger mechanisms, undoubtedly constituted a prime example of complex engineering by a terrorist organization. This was born out of tactical necessity but enabled by good organizational practices and access to materials, expertise, and places in which to leverage these. As Oppenheimer contends, "…it was in the series of homemade mortars produced by the IRA that its ingenuity was revealed, and its ability to supplement imported war-fighting equipment by developing its own."[79]

[74] O'Callaghan, The Informer, 86.
[75] O'Doherty recalls that on one occasion, the mortar shell 'went so far and buried itself underground that they couldn't find it'–author interview with Shane Paul O'Doherty.
[76] "Bombers," *Stirling Film Television Productions,* 2012, available at: *http://www.stirlingtelevision.co.uk/factual/bombers.html*.
[77] Author interview with former Northern Ireland law enforcement official 'D'.
[78] Author interview with former Northern Ireland law enforcement officials 'B' and 'C'.
[79] Oppenheimer, *IRA*, 227.

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Appendix A: PIRA Mortar Development								
Relevant Period		Designation	Date First Aware	Range	Payload	Other Salient Characters	Notable Associated Attacks	Notes
Prior to 1972	*No Capability*	'Spigot Grenade'[80]	Early 1970s		2 kg gelignite	- 15 cm pipe. - Fired from shotgun.		- Developed to deal with fortified police stations. - Viewed as too dangerous for volunteers to use.
1972-1974	*Intense Experimentation*	Flare 'Mortar'[81]	1973	'flew far'	'limited' amount of PETN	- 'Proto-mortar' using marine flares. - Replaced flare material with detonator, explosive and a fuse.		- Was not used beyond the town of Derry.
		Mark 1[82]	June 1972		250g commercial plastic explosive	- Mortar made up of 50mm copper pipe, with .303 cartridge in rear as propellant. - Triggered by driving spike against .22 cartridge (probably nail gun-type 'Hilti' cartridge) to ignite detonator. - Described as having an		- Would spin once took off. - No safety mechanism, so it was dangerous to user. - Failed to explode if fuse damaged by impact at wrong angle.

[80] Oppenheimer, *IRA*, 229.
[81] Author interview with Shane Paul O'Doherty.
[82] Author interview with Shane Paul O'Doherty; Geraghty, *The Irish War,* 88; Oppenheimer, *IRA*, 229.

						ingenious nose-cone fuse design.		
		Mark 2[83]	December 1972		1 kg commercial explosive	- 20cm long, 57mm diameter steel pipe. - 12-gauge shotgun cartridge as propellant. - 5 second delay from impact to ignition from a split fuse. - Modified, more reliable nose cone.	- First PIRA mortar fatality: British soldier attempting to defuse wayward mortar fired in Turf Lodge, Belfast in December 1972.	- Often fired through the roof of the target building. - Used 25 times in its first four months. - Accuracy still poor because of movement of the base-plate.
		Mark 3[84]	1973	250m	0.5 kg high-grade crystalline ammonium nitrate, boosted by aluminum powder	- 60mm mortar barrel; static firing pin and Hilti cartridge as detonator; 'J-cloth' (sodium chlorate-soaked) used as a propellant. - Accuracy increased through use of stronger base plate and configurable aiming quadrant. - Cut main explosive charge	- Attacks on Creggan Camp, Derry and Lisanelly barracks, Omagh in 1973 (16 mortars). - Failed attack on RUC Pomeroy barracks in August 1973 resulted in two IRA men killed.	- Highly volatile explosive tended to explode prematurely. - Unreliable, given to tumbling in flight. - Accuracy within 30m over 300m. - Used 105 times in 14 separate attacks in first six months.

[83] Malcolm Sutton, "CAIN Database of Deaths," December 10, 1972, available at: *http://cain.ulst.ac.uk/sutton/chron/1972.html*; Horgan and Gill, *From Bomb to Bomb-Maker*, 11; Oppenheimer, *IRA*, 229.
[84] Geraghty, *The Irish War,* 189; John Horgan and Paul Gill, *From Bomb to Bomb-Maker: A Social Network Analysis Model of the Socio-Psychological and Cultural Dynamics of the IED Process,* A Report Prepared for the Office of Naval Research supported by Grant PAGEN00014-09-1-0667 (University Park, PA: International Center for the Study of Terrorism, forthcoming), p.11; Ryder ,Chris, *A Special Kind of Courage: 321 Squadron – Battling the Bombers* (London: Methuen, 2006), 215; Author interview with Shane Paul O'Doherty; Oppenheimer, *IRA*, 229-230.

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						by half from previous model.		
		Mark 4[85]	1974	400m	0.45 kg ammonium nitrate, with up to 15% aluminum powder	- Extended range version of Mark 3. - Used greater amount of J-cloth as the propellant. - Contained ball bearings - No safety mechanism, so used as a traditional military mortar.	- Attack on base at Strabane (14 mortars did not function).	- Dangerous: could explode in tube and had no safety mechanism. - Was abandoned in six months.
		Mark 5[86]	1974	25m		- 'Bombard'-like.	- Never used.	- Discovered during raid on IRA workshop in Antrim in 1974.
		Mark 6[87]	1974	1,097m	1.36 kg explosive charge (often Semtex), detonated by .22 cartridge on impact	- 60mm calibre. - Standard launch tube, strong base plate and bipod. - .22 calibre cartridge initiated homemade gunpowder propellant after dropping mortar shell down tube. - Contained an impeller to arm itself during flight (advanced	- Cross-border attack on County Armaugh army observation post in 1974. - Extensive damage caused when thrown by hand onto roof of armoured vehicle in Divis Flats, Belfast in 1987. - 1994 Heathrow attacks.	- First reliable device (much safer and longer range minimized risk of detection). - Warheads in Heathrow attacks made from drainpipes with tailfins. - 28 intact units found in Belfast bakery in 1974; allowed security forces to gain

[85] Horgan and Gill, *From Bomb to Bomb-Maker,* 11-12; Geraghty, *The Irish War,* 189; Oppenheimer, *IRA*, 231.
[86] Geraghty, *The Irish War,* 190; Oppenheimer, *IRA,* 231.
[87] Geraghty, *The Irish War,* 191; Andy Oppenheimer, *30 Years of IEDs: The Operational Art of the Provisional IRA, PIRA–Lessons Learned Conference* (Stockholm: Swedish National Defence College, 17 April 2012); Oppenheimer, *IRA,* 170, 231-232.

						technology). - 8 aluminum fins. - Electric trigger system using remote control technology.		intimate working knowledge.
1975-1987	*Approaching Military Grade*	Mark 7[88]	1976		> Mark 6	- Longer version of Mark 6 (1m tube).	- Used against Army-RUC base at Crossmaglen in 1976.	- Poor flight stability because of length. - Sacrificed accuracy for greater payload.
		Mark 8[89]	1976		> Mark 6	- Longer version of Mark 6 (1m tube). - 'Cannibalized' version of earlier models.		- Poor flight stability. - Less sophisticated.
		Mark 9[90]	1976		5 kg explosive	- Produced from cut-down gas cylinders, so shorter, fatter profile. - Could be launched in groups of up to 10 tubes.	- October 1976 attack on Crossmaglen base; 7 mortars detonated. - 1977: 5 warheads off target landed in school grounds in Belfast.	- Sacrificed accuracy for explosive payload.

[88] Oppenheimer, *IRA,* 233.
[89] Ibid.
[90] Ibid., 234.

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		Mark 10[91]	1979	300m	Variously reported as 11kg (Boyne and Horgan) and 20kg-100kg (Geraghty and Oppenheimer) of explosive (1991 attack used "ANNIE" ammonium nitrate and nitrobenzene mix; sometimes Semtex)	- 150 mm diameter, 1.2m long warhead made from gas cylinders. - Fine black powder as propellant in base allowed accurate ranging. - Incorporated safety pin and weight-based safety mechanism with detonation on impact. - Detonated by electrical timers. - Multiple (up to 10) launch tubes ('set at varying angles for maximum target coverage' - Oppenheimer, p. 234).	- First fatality caused by mortar attack in South Armagh in March 1979. - Corry Square Police Station, Newry attack - April 1980. - 1985 Newry police station attack (9 killed). - Used in 1991 attack on British Cabinet on Downing Street.	- Often launched from the back of a truck. - Incorporated incendiary in base/launchers to destroy forensic evidence after launch. - Became 'workhorse' of mortar arsenal during 1980s, but 'wide angles' of attack meant that chances of civilian injury still high.
1988-1998	*Bigger and Better*	Mark 11[92]	1989	519m	10 kg (often ANNIE)		- Used in May 1989 against a British Army observation post in Glassdrumman, South Armagh.	

[91] Ibid, 193, 234-235, 320-321; Horgan and Gill, *From Bomb to Bomb-Maker,* 11-14; Geraghty, *The Irish War,* 192-195; Sean Boyne, "Uncovering the Irish Republican Army: Weapons," *Jane's Intelligence Review,* 1 August 1996, available at: *http://www.pbs.org/wgbh/pages/frontline/shows/ira/inside/weapons.html*, 3; Toolis, *Rebel Hearts*, 52.
[92] Geraghty, *The Irish War,* 192; Horgan and Gill, *From Bomb to Bomb-Maker,* 11-14; Oppenheimer, *IRA,* 236.

		(Mark 12[93])	1989		2.5 kg Semtex	- Not actually a mortar, since utilized direct fire from a horizontal position. - 75cm long. - Inertia fuse and triggered by command wire or timer. - Employed a shaped charge to pierce armour.	- Attack on Crossmaglen, October 1989.	- Ostensibly made British armoured vehicles obsolete.
		Mark 13[94]	1990	35m	36 kg	- Made from 45-gallon oil drum. - Launched from a spigot. - Short range meant required truck or tractor as a launching pad.	- First used in attack on Dungannon, May 1990.	- Sometimes used diesel fuel tanks as projectiles.
		Mark 14[95]	1992		20 kg of home-made explosive	- Made from top halves of two gas cylinders welded together.	- May 1992 attack on Crossmaglen base.	
		Mark 15[96]	1992	100-275m (depending on version)	70-75 kg of ammonium nitrate	- 360mm diameter cylinder. - Tube was 3 metres long. - Included coins as shrapnel.	- Army base in Ballygawley, County Tyrone, December 1992. - British base in Osnabruck, Germany in June 1996.	- 'Barrack buster'. - Brought down British helicopters in March, July 1994. - Improvised from widely available gas cylinder used

93 Author interview with Jim Cusack; Horgan and Gill, *From Bomb to Bomb-Maker,* pp.11-14; Oppenheimer, *IRA,* 236.
94 Oppenheimer, *IRA,* 237.
95 Ibid., 237; Horgan and Gill, *From Bomb to Bomb-Maker,* 11-14.
96 Geraghty, *The Irish War,* 193; Oppenheimer, *IRA,* 187, 238; Harnden, *Bandit Country,* 398.

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								for cooking / heating.
		(Mark 16[97])	1993	Effective 20-25m, up to 200m	900g Semtex	- Horizontal, direct fire weapon (like Mark 12). - Small and lightweight, no anchoring of base plate required (could be shoulder launched). - Shaped charge.	- July 1993 attack on William Street, Derry.	- Sometimes launched from under bonnet of car. - Unlike Mark 12, made from easily acquired parts with minimal machining needed.
		Mark 17[98]	1994-1995			- Described as one of the PIRA's most destructive weapons.	- Never used.	- Built during mid-1990s ceasefire.

[97] Oppenheimer, *IRA,* 238.
[98] Boyne, "Uncovering the Irish Republican Army: Weapons."