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Utilization of GIS in Tracking Disinterment and Movement of Unknown US WWII War Dead: Foundations for a Geospatial Approach to Addressing Commingled Remains

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By

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Utilization of GIS in Tracking Disinterment and Movement of Unknown US WWII War Dead: Foundations for a Geospatial Approach to Addressing Commingled Remains

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In the aftermath of World War II, the US was faced with the monumental task of finding and identifying over 405,000 service members who did not survive the conflict (McDermott, 2005, p. 1). Of these 405,000, 81,000 remain missing and 2,498 remain unidentified in cemeteries across Europe alone (American Battle Monuments Commission, 2022). Often, these individuals were interred and disinterred multiple times, crossing the continent in the journey from loss incident or battlefield to their final resting place. Commingling, the accidental mixing of remains, is an ever-present concern in the forensic identification of individuals from mass casualty incidents (Belcher et al., 2021). Each instance of disinterment and movement is an opportunity for commingling to occur. DNA testing is an oft relied upon method for distinguishing between individuals in these cases but can be time consuming and expensive. Further, when tests are conducted and results do not indicate a match with a suspected individual, this can compound the difficulty in establishing the unknown individual's identity. This project aims to establish a foundation for a spatially oriented approach to addressing commingling in these cases and aid in creating a "shortlist" of suspected individuals that may be a positive match. Through the creation of a geospatial tracking system, each unknown individual's path is traced in relation to known locations of origin and interment and can be analyzed in tandem with all unknown individuals that they have crossed paths. Likelihood of identification is inversely proportional to the interval between death and forensic analysis (Steere & Boardman, 1957). This is to say that identification becomes increasingly difficult and less likely to succeed as time grows between the death of an individual and an attempt at identifying them. Ultimately, time, volume of effort, and funds are limited resources in the mission to identify the US's remaining missing service members. The creation of

tools that require fewer resources and can ease more intensive identification methods is a pursuit highly relevant to our efficiency in identification.

Acknowledgements

This thesis addresses the progress and future uses of an ongoing project in partnership with Oak Ridge Institute of Science and Education (ORISE) and the Defense POW MIA Accounting Agency (DPAA).

To begin, I'd like to acknowledge and thank the US service members who gave their lives to fight for the greater good, and for the future we have now. Their sacrifices surpass what most of us will ever give, and it is them we should thank that this is the case. There is no greater privilege than to have an opportunity to help and pay tribute to them. In particular, I'd like to acknowledge 1st Lt. Frank Fazekas Sr., Frank Jr., and his family for allowing me a point of entry into understanding firsthand why this still matters to people and their communities. I am happy to say 1st Lt. Fazekas is memorialized at the Ardennes American Cemetery on the Tablets of the Missing, marked as having been found, and now reinterred at Arlington National Cemetery. Many hands were involved in his recovery, from the UW team to the multitude of people in the lab and DPAA who orchestrated both our partnership and his official identification. It was an honor to get to be one of them.

I'd also like to acknowledge Chuck Konsitzke, Ryan Wubben, and Gregg Jamison at the University of Wisconsin MIA Recovery and Identification Project for allowing me to be a part of their team for the past six years. Their dedication to the UW MIA RIP project is incredible, and a great inspiration for others. Being in the field with the team is like being with family. I actually *like* my family, so that's saying something.

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Chapter 1: Introduction

In the aftermath of World War II, the US was faced with the monumental task of finding and identifying over 405,000 service members who did not survive the conflict (McDermott, 2005, p. 1). The US Army's Graves Registration Service had a large role in addressing this problem from its mobilization in December 1941 to its semi-cessation in 1951 (Steere,1951, p. 23). This mission was the impetus for the creation of the first Central Identification Laboratory, which still stands on Joint Base Pearl Harbor-Hickam (JBPHH) on O`ahu, HI, now part of the Defense POW/MIA Accounting Agency (DPAA, 2022). The DPAA continues to work toward a similar goal to the American Graves Registration Command (AGRC) - the recovery and identification of the remaining missing service members in a world-wide context. Due to the immense effort of the AGRC and many after them, only 3% of deceased WWII service members remain unidentified, buried in cemeteries across Europe and the Pacific (Steere, 1951).

There are numerous obstacles to identifying these remaining individuals and a variety of potential methods to be tried to subvert them. Among these obstacles is commingling of remains. Commingling, the often-accidental combination or incident-related mixing of the remains of multiple individuals, is a persistent challenge that is difficult to avoid, let alone track. It is the intent of this thesis to begin to develop a geospatial approach to track the movements of unidentified WWII service members to investigate the potential degree of commingling of individuals. This geospatial approach may help establish a "shortlist" of who they may have come into contact with, and therefore potentially commingled, along their eventual route to a permanent cemetery. After death and having a legal determination of "unidentifiable," each unknown individual was assigned an X-number upon their burial in a temporary AGRS cemetery, by which they are known to this day.

To provide adequate background, Chapter 2 discusses the history of recovery and identification of US service members from the European Theater of Operations, recent attempts at overcoming identification challenges, modern methods of personal identification of unknown deceased individuals, commingled remains and challenges commingling imposes, and Geographic Information System (GIS) as applicable to the scope of this project are addressed. Chapter 3 explains in detail via a discussion of the nature of the data used and how they have been adapted into a geospatial format using GIS, specifically ArcGIS Pro 3.0.0. In Chapter 4, two case studies of the application of this method of tracking unknown individuals are demonstrated via data from the Netherlands American Cemetery (NAC) and Ardennes American Cemetery (AAC), Belgium. Chapter 5 provides a discussion of the limitations of the data and structure of the project in addition to current capabilities. Finally, Chapter 6, provides conclusions from the current state of the project and a discussion of future directions.

For reference and clarity, the following tables of frequently used terms and acronyms are provided for readers.

Table 1. Table of Major Acronyms

Abbreviation	Full Title
AAC	Ardennes American Cemetery (Neuville-en-Condroz)
ABMC	American Battle Monuments Commission
ADSEC	Advanced Section (of the Communications Zone, European Theater of Operations)
AGRC	American Graves Registration Command
AGRS	American Graves Registration Service
CIP	Central Identification Point
DPAA	Defense POW/MIA Accounting Agency
ECCP	European Casualty Clearance Plan
FM	Field Manual
GIS	Geographic Information Systems
GRS	Graves Registration Service
IDPF	Individual Deceased Personnel File
NAC	Netherlands American Cemetery (Margraten)
POW/MIA	Prisoner of War/ Missing in Action
SIP	Subordinate Identification Point
TM	Training Manual

Table 2. Terms

Term	Usage
Final Cemetery	The last cemetery an X travels to and remains interred at until identification

Movement	At least one segment of the path an X took from Point of Recover to Final Cemetery. Movements are made up of segments
Point of Convergence	A location at which at least two Xs may have been contemporaneously
Point of Recovery	The location an Xs remains were retrieved from
Segment (of a movement)	A portion of a movement from a single location to another
X	An unidentified US servicemember (Plural: Xs)
X-Files	Documentation associated with an X

Chapter 2: Background

This thesis touches on a variety of topics, all of which should be discussed before proceeding to discussion of the data, methodology, and case studies. The following section covers relevant aspects of forensics, the history of recovery and identification in the European Theater of Operations, procedures of the American Graves Registration Service (AGRS) during wartime, a discussion of the Solvability & Resolvability project from which much of this project's data are derived, and a brief discussion of GIS. Forensic anthropology is at the core of the identification process, providing reliable methodology to base identifications on. Postmortem data in X-Files, the collection of documents associated with a set of unidentified remains, are only useful if they can be reliably and scientifically compared to antemortem records and historic documents. Beyond this, understanding the actions and methods employed by the AGRS throughout WWII and AGRC from 1945 to 1951 provides important perspective on what issues may be at play in the mission to find and identify remaining US missing service members. The actions of the American Graves Registration Service (AGRS) and American Graves Registration Command (AGRC) are not insignificant. Choices made and procedures deigned appropriate from 1941 to 1951 affect our ability to identify individuals into the present. Prior work toward understanding how to address challenges in finding and identifying missing service members, namely the Solvability & Resolvability project, has informed many aspects of how this thesis proceeded and are discussed in its own section. Lastly, GIS is a core component of this research, but a subject that can be intensely complicated. A very basic overview of GIS is provided, with a brief discussion of how GIS applies to this project.

Forensics and Personal Identification

Determining an individual's identity from a set of remains is a core focus in the field of forensic anthropology and much effort has been devoted to creating and improving identification methods. The methods often employed in the identification of US war dead may consist of biological profiles (sex, stature, age, population affinity), forensic odontology, trauma and pathologies, DNA testing, isotope testing, and consideration of other individuating traits not covered via the prior methods (Belcher et al. 2021, pp. 3-12). Other methods may be employed where appropriate and the prior list is in no way exhaustive of either the methods used to identify US war dead or of the wide variety of available methods.

The biological profile is a set of traits that can be determined from skeletal remains, often examined as potentially individuating information. Traits consist of an individual's sex, stature, age, and often population affinity (Belcher et al., 2021, p. 7). In the context of the identification of US war dead, particularly of the WWII era, the biological profile may be of use in establishing basic details about the decedent but is often not an individuating piece of information. This is due to the similarities of elements of the biological profile between service members, i.e., "…male, White or Black, early 20s in age, around 5’10” to 6” tall" (Belcher et al., 2021, p. 7).

Forensic Odontology and dental records are further sources of identifying information. In mass casualty cases with victims of similar biological profiles, dental conditions can be more varied, allowing greater insight into individual identities than the biological profile alone (Belcher et al., 2021). Antemortem and postmortem dental charts may be compared, with matches contributing to a positive identification. Dental charts are common in individual personnel files, documenting any dental anomalies (i.e., cavities, crowns, missing teeth, etc.) noted via dental chart, although x-rays were extremely uncommon if nonexistent throughout WWII (Belcher et al., 2021; Shiroma, 2016). In a study on identifications of victims of the USS Oklahoma, Shiroma notes that common discrepancies such as differences in documentation of surface restorations, antemortem tooth loss, interproximal restorations, errors in the dental charts themselves, and dental restorations performed on deciduous teeth may all be factors that may affect the accuracy of identification (Shiroma, 2020).

Medical records, like dental records, may also hold individuating information provided that the condition was noticeable enough to merit documentation antemortem and have some pathology that manifests in the skeleton. For example, a bone with evidence of a healed break may be matched up with documentation of the same injury antemortem. This correlation may aid in indicating that the remains are consistent with being from the referenced individual. Additionally, particularly for service members enlisted during the Korean War, chest radiographs of the sternum, clavicle, and thoracic vertebrae taken upon enlistment may be compared to skeletal remains and matched up for potential identifications (Belcher et al., 2021, p. 9).

Mitochondrial DNA (mtDNA) and Next-Generation DNA sequencing are powerful tools when they can be applied to a case; however, there are a few factors that may complicate their use. DNA testing is an important but resource-heavy addition to the identification toolkit - there is no practical way to test every osseous fragment, or to compare every single DNA sample (Belcher et al. 2021, p. 10). MtDNA specifically examines the DNA of the maternal line from a given sample (Belcher et al., 2021, p. 10). Due to this, results of a test are only useful in comparison to a familial sample from the maternal side of the individual's relatives. In cases where appropriate familial samples are inaccessible, mtDNA may not prove useful for identification as no comparison can be made. However, when it can be strategically employed, the results are informative and may contribute significantly to a positive identification (Belcher et al., 2021 p. 10).

Addressing Commingling and Taphonomy

Commingling is the core concern of this thesis. Defined by White and Folkens as "Bone assemblages containing remains of multiple individuals, often incomplete and fragmentary" (2005, p. 420), commingling complicates the identification process by requiring additional work to separate individuals as well as identify them. Particularly for sets of fragmentary remains, it may be difficult to establish if commingling has occurred or if the assemblage present is from only one individual (Devlin & Herrmann, 2017). Fortunately, there are many methods that may be used to attempt to address commingling and correctly segregate individuals (Belcher, 2021a). In a laboratory setting, commingling can be addressed via non-metric and metric methods. Pair-matching (both visual and via articulation), observation of taphonomic patterns, trauma, and refitting are common examples of non-metric approaches to addressing commingling (Belcher, 2021a). However, descriptive statistics and other quantitative methods may also be employed (Belcher, 2021c).

Commingling can be assessed with descriptive statistics via calculating the Minimum Number of Individuals (MNI), the Lincoln-Peterson Index (LPI), and Most Likely Number of Individuals (MLNI), a modification of the LPI (Adams & Byrd, 2014; Belcher, 2021c). Whereas the MNI calculates the fewest possible individuals that could account for the commingled assemblage, the LPI and MLNI aim to account for natural data loss (i.e., missing skeletal elements) to estimate the number of individuals represented in an assemblage more accurately (Belcher, 2021c). Further metric methods may consist of quantitative pair matching via use of osteometrics, achieved by comparing measurements of commingled elements to statistical models derived from data on relationships between size and shape of skeletal elements from a given reference population. In other words, remains are assessed for likelihood of association with each other (Belcher, 2021c). This method may be applied to any skeletal element with sufficient data from appropriate reference populations.

Non-metric (or visual) pair-matching is conducted by sorting and comparing skeletal elements by size, development, and anatomical side (Belcher, 2021b). After going through an initial sorting process, an element from one side is compared to an element from the opposite and assessed for similarity and therefore possibility of originating from the same individual (Belcher, 2021b). Further, elements in an assemblage may also be examined to assess whether the facets articulate well enough with each other that the elements may be from the same individual (Belcher, 2021b). Once the assemblage is satisfactorily sorted out enough to represent the individuals present, a process of elimination can aid in deducing which individuals remaining duplicated elements originated from (Belcher, 2021b). Pathological conditions and different varieties of trauma may also lend insight into whether elements are from the same individual, provided the condition manifests distinctly enough in the elements present (Belcher, 2021b).

Changes in appearance due to taphonomic effects may be used very cautiously to assess whether certain elements may be associated but should only be used as supporting evidence rather than a primary means of association (Belcher, 2021b). Taphonomy and taphonomic effects refer to the variety of changes remains may undergo postmortem (Efremov, 1940). These changes may range from charring due to exposure to fire, staining from exposure to soil, rust stains from clothing fasteners, and any other phenomenon, environment, or interaction with outside forces (Belcher, 2021b). For example, a rust stain from an article of clothing may extend across multiple skeletal elements and may be used in support of association (Belcher, 2021b). Furthermore, certain taphonomic effects may be more associated with some manners of death than others. In a study examining trauma present on the remains of 35 US WWII service members, Palmiotto et al. found that "Thermal alteration of bone, though uncommon, was observed only in aircraft deceleration cases (8%)" (2020, p. 1810).

Propeller-driven aircraft crashes (rapid deceleration events) and bombings (blast trauma) often result in significant trauma and fragmentation of remains (Palmiotto et al., 2020). The amount of remains recovered may vary depending on incident type, with a tendency for greater fragmentation and lower recovery rates in aircraft crashes and the inverse for instances of blast trauma (Palmiotto et al., 2020). Completeness of remains directly affects the ability of analysts to determine a biological profile, with Palmiotto et al. noting that 90% of blast cases in their sample were complete enough for a biological profile (2020). By comparison, biological profiles could be determined for only 29% of aircraft cases from the same sample (Palmiotto et al., 2020). With taphonomy in mind, fragmentation provides an opportunity for elements from the same individual to be exposed to different taphonomic effects. This consideration is a clear reason toward use of taphonomic effects only as supporting evidence of association that cannot be used alone. Further, Palmiotto et al. note that "Widespread trauma is found predominantly in aircraft cases (67%) and less frequently in blast cases (27%), in which trauma tends to be more localized" (2020, p. 1809). This suggests that the manner of death, rapid deceleration due to an aircraft crash or blast trauma from explosive ordnance, may be inferred from the trauma presented (2020). Patterns of trauma are distinct between the two types of events, with aircraft crashes presenting blunt force trauma from conflicting directions and blast trauma presenting blunt force trauma from one primary direction, possibly associated with secondary blast trauma such as projectiles (i.e., shrapnel) (Palmiotto et al, 2020).

History of Recovery & Identification in the European Theater of Operations

A military organization responsible for recovering and identifying deceased service members has existed in some form since the American Civil War, under a variety of titles and structures. The Graves Registration Service (GRS) was the World War I predecessor to the American Graves Registration Service (AGRS) of WWII. After WWI, the GRS successfully identified 96.5% of deceased personnel from conflicts across Europe (McDermott, 2005; Steere & Boardman, 1957). In other words, only 3.5% of individuals recovered from WWI conflicts remain unknown. The success of the GRS in WWI primed the Office of the Quartermaster General for the implementation of the AGRS. The AGRS was modeled on the structure of the GRS upon its activation during WWII. The AGRS transitioned from a Service to a Command upon conclusion of active conflict in the European Theater of Operations and became the American Graves Registration Command (AGRC) from 1945 to 1951. A timeline of the GRS, AGRS, and AGRC, associated activities, and active organization name is provided in Figure 1. As the data for this project consists of losses on the European continent, this section focuses on the activities of the AGRC in the European Theater of Operations during WWII.

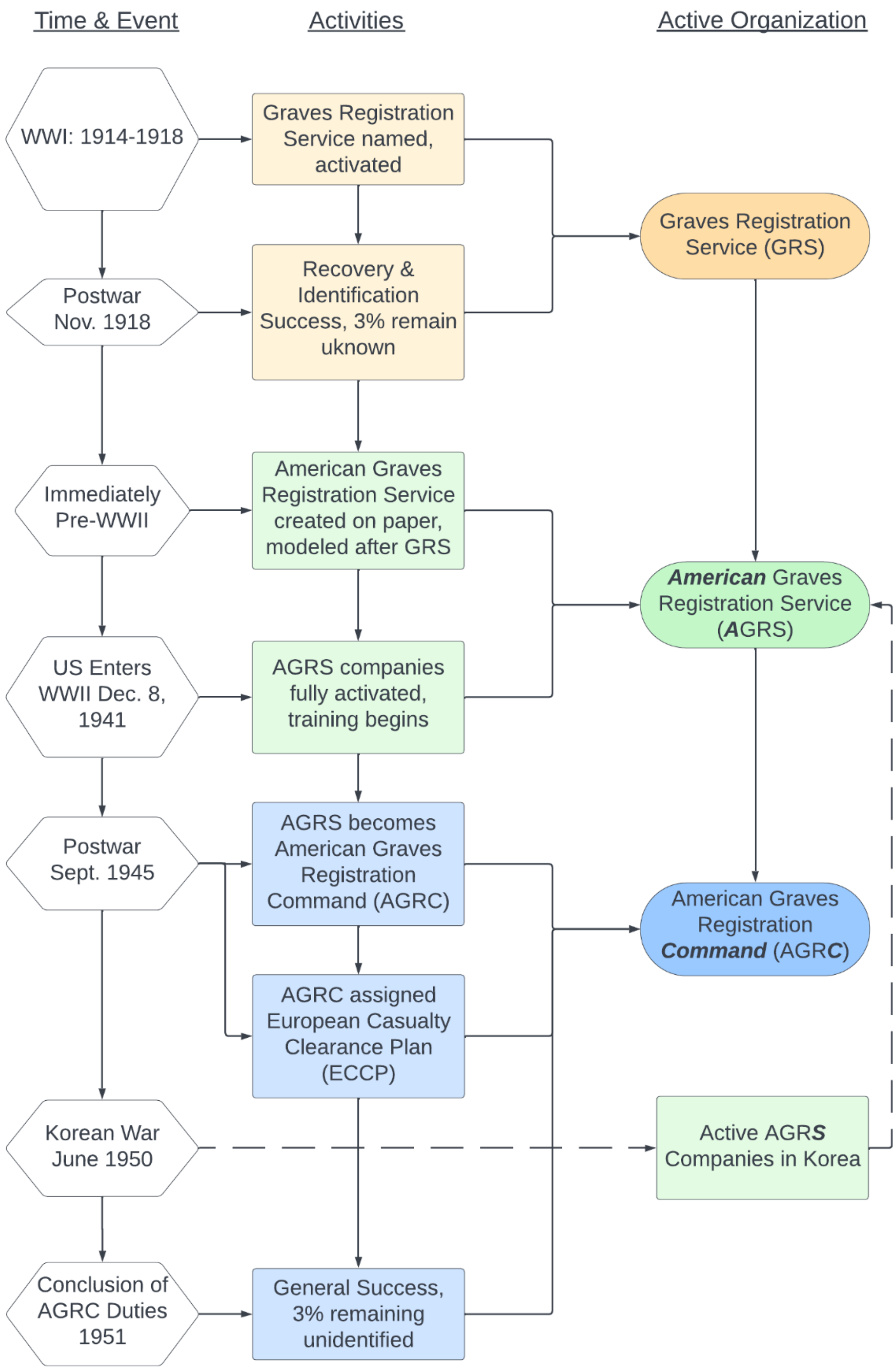


Figure 1. GRS, AGRS, and AGRC Timeline and Activities

The AGRS was activated on the 9th of December 1941, immediately after the US's entry into World War II. The first AGRS company to see service in WWII was activated on March 28th, 1942, although little training beyond Training Manual (TM) 10-630 was available at the time (Steere, 1951, p. 29). By February 1943, five of the then twelve activated AGRS companies had received training (Steere, 1951, p. 30). Steere notes this as a "lag of one year in supplying technically trained graves registration and combat forces" (Steere, 1951, p. 29). Additionally, some complications were derived from the training manual itself. "TM 10-630 left much to be desired", serving less as a pocket-guide and more as text describing adapted procedures from the WWI GRS (Steere, 1951, p. 23). The first version of the manual used for the AGRS, TM 10-630, was written in September 1941 and received updates in June and October of 1942, 1943, February and March of 1944, and finally in 1945 (Steere, 1951, p. 23). TM 10-630, TB 10-630-1, TB 10-630-2, and Field Manual (FM) 10-63 outlined the procedures for the creation of temporary cemeteries and interments, as well as loose procedure for identification attempts prior to the establishment of CIPs or Laboratories as they would be implemented post-war (Steere, 1951, p. 24).

In this regard, the final 1945 iteration of FM 10-63, which will be referenced further, can likely be understood as what was considered best practice at the time. Versions were updated as understanding of best practice and War Department-mandated procedures changed, although it is difficult to determine what exactly these changes were and their larger effect on identification without review of each iteration. The procedures for identification would be heavily refined upon the creation of Central Identification Points (CIPs). CIPs were, as titled, central locations used as labs for analysts to examine and document remains, collect data (such as dental charts, biological profile, personal effects, etc.), and attempt to establish the identity of the deceased (McDermott, 2005; Steere & Boardman, 1957). The first CIP was established in Strasbourg in 1946 and Neuville-en-Condroz shortly after, although the Margraten Subordinate Identification Point (SIP), a morgue at Neuville-en-Condroz, and other smaller morgues were in use during WWII (Steere & Boardman, 1957, p. 191). The establishment of more extensive and centralized CIPs was prompted and strongly encouraged by Dr. Harry L. Shapiro who was brought onto the project to advise on identification methods (McDermott, 2005, p. 4).

Postwar efforts of the AGRS were clearly needed, resulting in its official transition from a Service (AGR*S*) to a Command (AGR*C*) in early 1945 (Steere & Boardman, 1957, p. 172). Further preparations were set in motion with the European Casualty Clearance Plan (ECCP), approved and enacted on July 12th, 1945, however it would not be until November 6th, 1945 that the AGRC was designated the sole organization to carry out the ECCP (Steere & Boardman, 1957, p. 169). This prompted an intensive review and compilation of all available documents concerning missing service members (Individual Deceased Personnel Files, Missing Air Crew Reports, among others) in order to take stock of the task at hand (Steere & Boardman, 1957, p. 196).

Four Zones were established, based, in part, on previous field commands and sectors, with Germany and the Mediterranean serving as two additional areas, shown in Figure 2 (Wood & Stanley, 1989, p. 1368). The first zone was comprised of the Netherlands, Belgium, and Luxembourg, the second zone of approximately the northwestern third of France, the third zone the remaining portion of France in addition to Switzerland, and the fourth zone of the British Isles and Ireland (Steere & Boardman, 1957, p. 224). Systematic region-by-region sweeps in search of cemeteries and remains began in November 1945, running through late 1946 (Steere & Boardman, 1957, p. 201). Sweeps through the established zones can be considered to have taken place in three stages: "Propaganda" (what would likely now be called "community outreach"), Investigation, and Disinterment (Wood & Stanley, 1989, p. 1367).

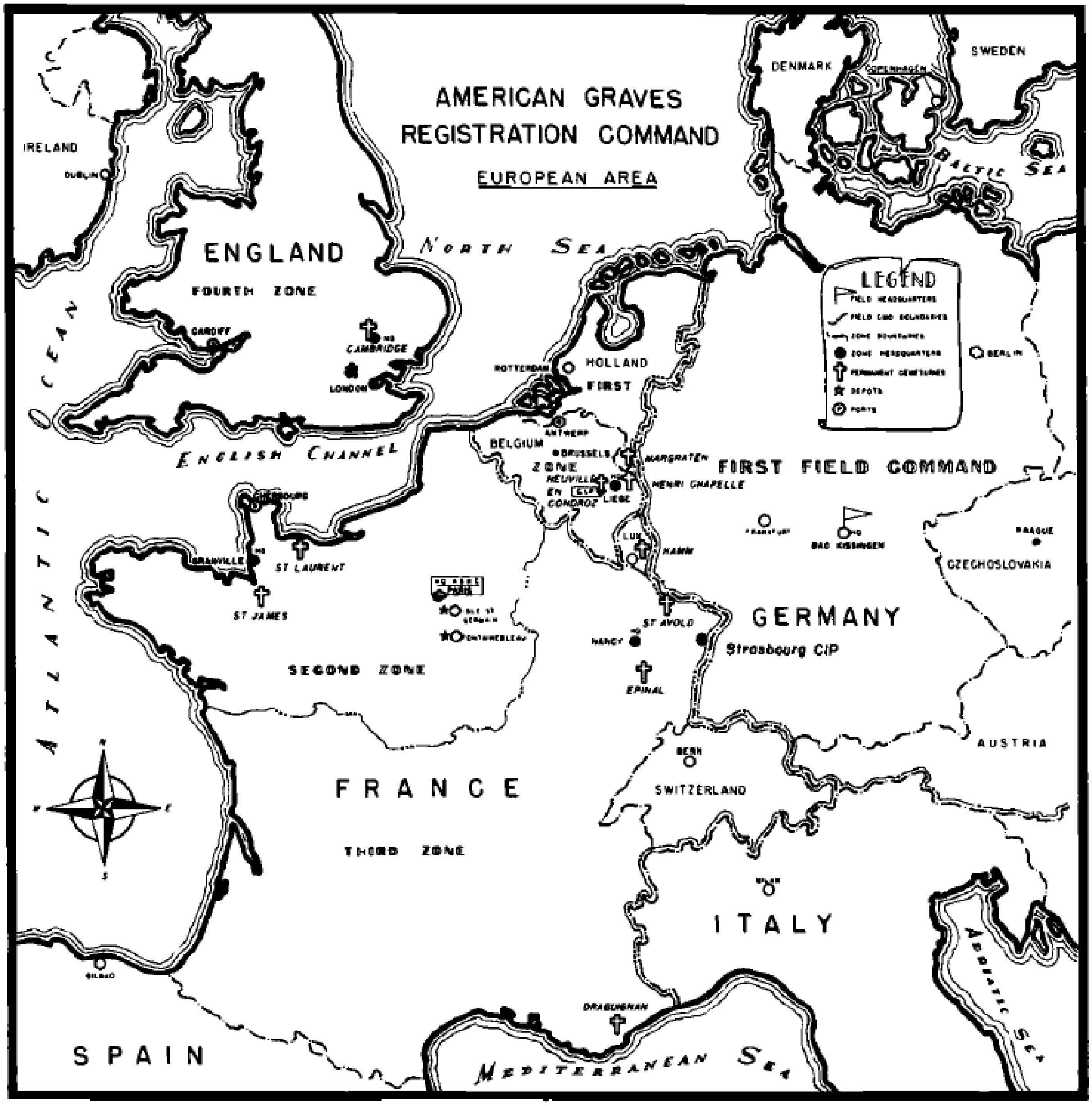


Figure 2. Zone map, (Wood & Stanley 1989, p. 1368)

The Propaganda phase consisted of teams of AGRC representatives visiting locations throughout their respective zone to collect information on possible locations of the remains of US Service members (Steere & Boardman, 1957, p. 228). Their outreach efforts included distributing multi-lingual posters, radio ads, and interacting with community leaders to explain the mission of the AGRC and inquire as to what pertinent information they may have (Steere & Boardman, 1957, p. 186). Once this information was compiled, the Investigation phase began. The AGRC implemented searches in areas now suspected to have the remains of US Service members and any remains or graves located were further documented (Steere & Boardman, 1957, p. 187). The remaining remains were later exhumed and evacuated during the third phase, Disinterment (Steere & Boardman, 1957, p. 187).

In August 1946, a Central Identification Point (CIP) was created in Strasbourg, under the supervision of C. Simonin, a European forensic scientist (Wood & Stanley, 1989, p. 1369). All exhumed remains and associated materials were sent to the Strasbourg CIP before the creation of a second CIP at Neuville-en-Condroz in 1947, under the supervision of F. Vandervael (Steere & Boardman, 1957, p. 625; Wood & Stanley, 1989, p. 187). Here, disinterred remains would be intensively scrutinized by teams of analysts, examining any associated clothing, associated items, potential identification media, or indications toward the individual's identity (McDermott, 2005, p. 4). This would be followed by an anatomical assessment, noting height, approximate body mass, and any other notable injuries or characteristics (McDermott, 2005, p. 4). Identifications were considered complete based on the presence of identification media (i.e., stamped tags, bracelets, etc.) so long as no contradictory evidence was present (McDermott, 2005, p. 5). If identification media was not present and other personal effects did not aid in an identification, an X number was assigned (McDermott, 2005, p. 5).

By early 1948, the majority of remains had been located and either identified or assigned an X number, with the remaining unlocated cases being notably complicated due to their location or conditions of death (Steere & Boardman, 1957, p. 236). September of that year marked a total of 47,851 individuals repatriated to the US from Europe, in a series of shipments out of England, Cherbourg, and Antwerp, with the total rising to 62,000 by the end of the year (Steere & Boardman, 1957, p. 363). Meanwhile, further recovery efforts continued in earnest until March 1949, after which the second, third, and fourth zones were disbanded, moving all personnel to Headquarters in the first zone (Steere & Boardman, 1957, p. 236). Of the ten total permanent AGRC cemeteries in Europe, Henri-Chapelle

Cemetery, in the first zone, was the first cemetery to receive permanent burials in 1948 and to be transferred from the AGRC to the American Battle Monuments Commission (ABMC) in late 1949 (Steere & Boardman, 1957, p. 320). In every case, the transition from temporary to permanent cemetery necessitated exhumation of all temporarily buried remains, placement of the remains in a casket if not already, and temporary storage of the remains as the cemetery site was graded and cemetery constructed (Steere & Boardman, 1957). Margraten Cemetery received its first set of final internments on December 1st, 1948 and was transferred to the ABMC on December 15th of the same year (Steere & Boardman, 1957, pp. 320-323). Neuville-en-Condroz was the last cemetery to receive permanent interments, beginning in March 1949, and to be transferred to the AMBC, on June 15th, 1951 (Steere & Boardman, 1957, p. 324).

December 31st, 1951, marked the end of the AGRC's work in Europe, resulting in a return of 86,828 service members to the US and burial of 60,719 service members in cemeteries across Europe (Steere & Boardman, 1957, p. 365, 336). This constituted the largest repatriation of service members from a single theater of operation in the world (Steere & Boardman, 1957, p. 365) Only 3% of recovered service members remained unidentified globally, a rate comparable to the work of the Graves Registration service in WWI (McDermott, 2005, p. 7). When limited to the European Theater of Operations, the percentage of unidentified individuals drops to 1% (Wood and Stanley, 1989, p. 1369). Although AGRC activity ended in 1951, this by no means marks the end of US recovery and identification operations in Europe, which continue to this day.

AGRS Procedure During Wartime

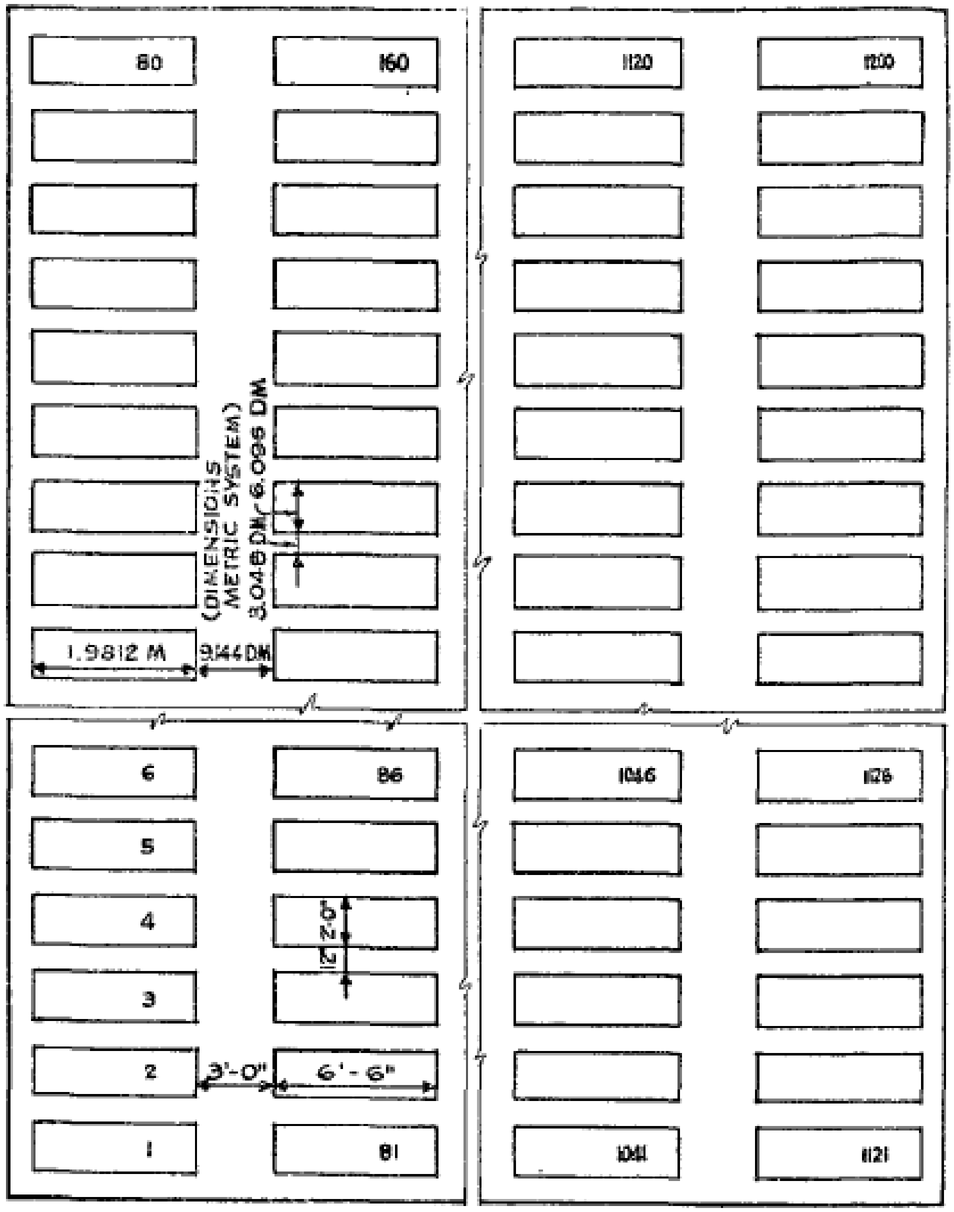
The basic functions of the AGRS are stated to be "…the physical collection, evacuation, identification, and burial of battlefield dead; the collection and disposition of personal effects…" (US War Department, 1945, p. 7). In effect, this would constitute the procurement of bodies from various locations, including battlefields and hospitals, initial documentation of the deceased if possible, and finally toward a CIP where identification would be attempted for those still unidentified prior to interment in a temporary cemetery. Remains were removed from battlefield areas by a "Collection Squad" and moved to the aforementioned central collection locations by an "Evacuation Squad", with the Evacuation Squad leader and attached medical technician responsible for the first attempt at identification (US War Department, 1945, p. 9).

FM 10-63 addresses documentation and interment procedure for individuals with known identities but additionally outlines procedures for interment if an individual cannot be immediately identified (US War Department, 1945, p.2). Standardized forms were used, documenting basic data such as the deceased's name, rank insignia, and organization as well as details on date of death, date of interment, and location if known (US War Department, 1945). If an identification was not immediately made, it was often due to a lack of identification tags or other identification media (i.e. "dog tags" or bracelets bearing the individual's name, names or rank insignia on uniforms, or other personal effects with inscriptions) the condition of the remains, or other limiting factors. Procedure dictates that a complete set of fingerprints be taken for every unidentified individual, as well as documentation of any anatomical characteristics, and a dental chart be created if possible (US War Department, 1945, p.24). Once interred, the graves on either side of the unknown deceased were to be noted on the same form (included in Appendix B) (US War Department, 1945). In cases where multiple individuals have their identification media destroyed, the procedure was to assign sequential X numbers to the group of unknown individuals (US War Department 1945, p. 23). Unknown individuals were to be buried in individual graves and assigned the next sequential X number from the cemetery of their burial (US War Department, 1945, p. 26). However, there are instances of X numbers assigned as X-0000a and X-0000b when originating from the same location or context in the data used in this project.

Once the recovered individuals had been processed at a CIP and either identified or assigned an X number, temporary cemeteries were laid out following a standardized plan. FM 10-63 instructs that the cemeteries should be laid out as consistently as possible in the format shown in Figure 3, with graves at a minimum five feet depth, interments with heads facing the same direction, markers placed at heads, and graves numbered sequentially (US War Department, 1945, p. 14). Schematics for the construction of grave markers are provided in Appendix B. Limitations for cemetery size were dependent on the duration of conflict in the area and available land and on occasion the trench method of burial was a necessary alternative to the standard temporary cemetery layout, shown in figure 3 (US War Department, 1945, p. 30). FM 10-63 notes that burials of fewer than twelve individuals are considered "Isolated Burials" and should be avoided, if possible and unless in emergencies, in favor of consolidation into larger cemeteries (US War Department, 1945, p. 30). Burials of twelve or more are considered temporary cemeteries (US War Department, 1945, p. 30).

The importance of prompt burials is stressed in FM 10-63, noting that burials are crucial for both morale and sanitation (US War Department, 1945, p. 16). Once a deceased individual had been located, an AGRS unit was to follow the procedures set out in the most recent TM or FM on hand, with variations as merited by the situation. If evacuation were impossible, such as in an active battlefield area, an individual would be interred in a shallow grave, marked with a stick, rock, or bayonet and helmet, often without time to search the body for identifying personal effects (US War Department, 1945, p. 16). These individuals would be recovered later once hostilities in the area had ended and it was safe for GRS units to proceed with activities.

Opportunities for commingling or misidentification begin early in the identification process. FM 10-63 notes that identification tags may be "matched up" if found separate from a body on the battlefield (US War Department, 1945, p. 26). Although FM 10-63 dictates that this process should be done carefully and ideally with additional lines of evidence supporting the tag/decedent match, this introduces another opportunity for misidentification or mismatching. Further, unidentified individuals were often disinterred and reinterred multiple times prior to reaching a permanent cemetery, offering yet more opportunities for remains to be commingled.



CEMETERY PLAN

Figure 2. Cemetery plan.

Figure 3. FM 10-63 Cemetery Map

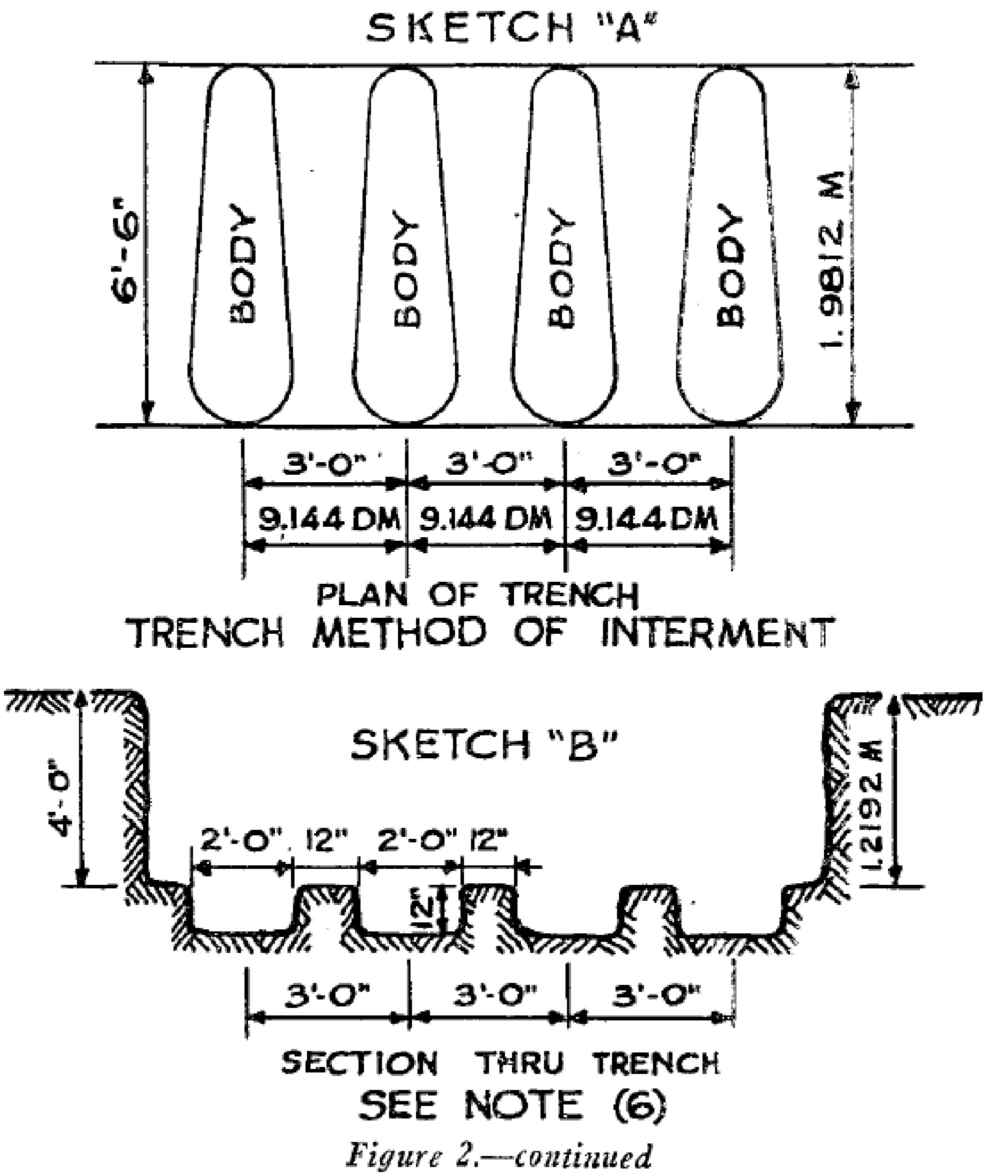


Figure 4. FM 10-63 trench method of interment

Solvability & Resolvability

This is not the first attempt to address the challenges posed by identifying unknown individuals by mapping or visualizing their relationships to other unknown individuals and locations. The most recent iteration known to the author took place in circa 2013 as the "Solvability & Resolvability" (S&R) project. The S&R project was focused on the creation of databases of information related to missing or unidentified service members, including ante- and post-mortem data, geographic locations, dates, and other available information. The intent was that these databases be used by analysts at various stages of progress on cases, as early as planning stages and as late as during the identification process. The project was eventually shut down in 2015 (Cole, 2019, p. 425).

Solvability, as defined by Paul M. Cole of the S&R project, amounts to an assessment of the available data regarding a missing individual and, based on the information present, an assessment of the likelihood that finding and identifying the individual is possible (2019, p. 353). In this case, the identity of the missing individual is known, as are other details, but the location of their remains is unknown or currently inaccessible.

Resolvability, again defined by Cole, amounts to an assessment of a set of remains and their associated data to estimate the possibility that the current data is enough to make a positive identification or at the very least consideration for further testing (2019, p. 353). Resolvability is highly dependent on the condition of the preservation of remains - the presence or absence of teeth, the taphonomic processes endured by the set of remains and its influence on the potential of DNA evidence, notable pathologies, and the skeletal elements present are some of the numerous factors. An unknown variable in resolvability is the potential for commingled remains. At various points while remains were interred, disinterred, reinterred, etc., skeletal elements may have been mixed up, lost, or entire identities (X numbers) confused. Mapping the movement of Unknowns (Xs) was also attempted by members of the S&R project, although with open-source social networking software NodeXL (Cole, 2019, p. 361, Social Media Research Foundation, 2016). Figure 5 an example of the non-geospatial mapping of relationships between Xs and locations as created by prior work on this data. Although it does display relationships between individuals and locations, it lacks clarity or ability to investigate these connections further. This may not have been the case upon their initial creation, but due to changes in software and researchers over time, the images are exceedingly difficult to put to any definitive use. It does begin to illustrate the ideas that this project is addressing with ArcGIS Pro by beginning to look at relationships between locations, but does not go into further depth. Additionally, the process of creating the "maps" showing relationships between cemetery movements required an immense amount of data mining from the X-Files and produced numerous excel spreadsheets that became the data for this project. The concepts of solvability and resolvability are still relevant, as mapping X movements geographically attempts to examine some similar concepts to the resolvability portion of the S&R project.

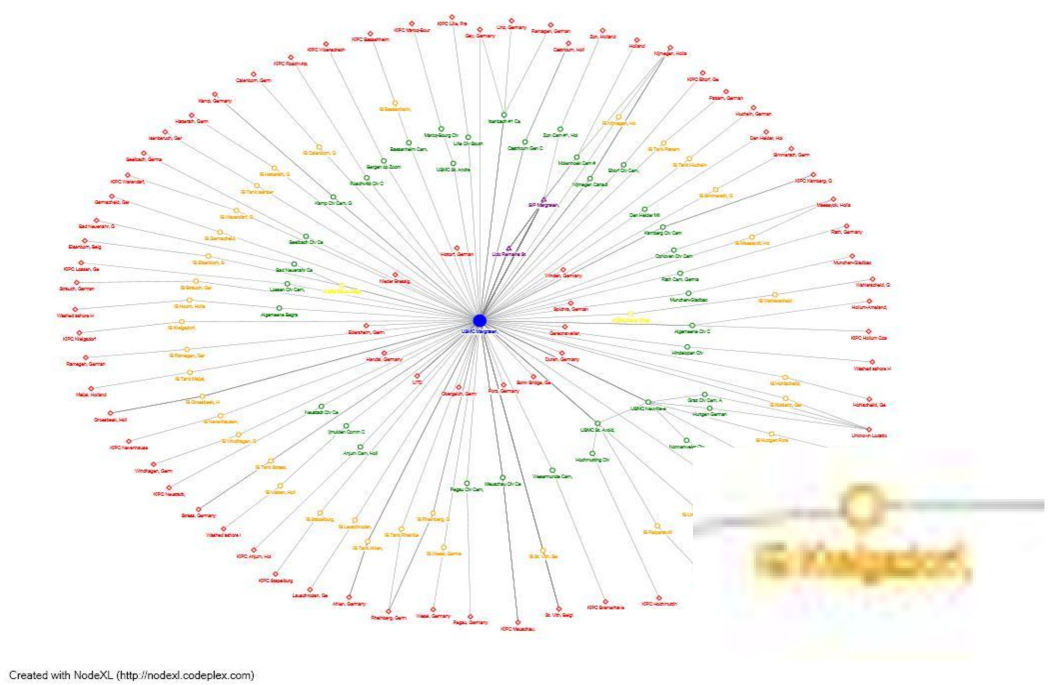


Figure 5. Initial map of locations funneling into Margraten, NL cemetery and detail illustrating the difficulty in reading the text due to pixelation.

A Brief Note on GIS

GIS stands for "Geographic Information Systems" and is in reference to a variety of approaches, programs, and forms of data that can be used for spatial analysis on numerous scales (Wheatley & Gillings, 2002). It can be employed for any number of uses requiring spatial and data analysis and management. Due to the inherent complexity of GIS and challenges in accurately describing it, the following description by Wheatley and Gillings (2002) is provided:

> GIS, then, are computer systems whose main purpose is to store, manipulate, analyze, and present information about geographic space. Of course, this is a definition that could apply to many technologies, for example computerized databases or even paper maps. This is because the individual components that make up GIS are not very new. In fact, they have been available for considerable time as, for example, computer-aided cartography, computer-aided design (CAD), image processing, and database management systems (DBMS) (p. 8).

Furthermore, regarding GIS Wheatley and Gillings note that “It comprises a combination of several different software technologies” akin to a “spatial toolbox” (2002, p. 8) It should be noted that there is some contention regarding defining GIS as such, but for the purposes and scope of this thesis, this definition of it will be sufficient.

In a very superficial sense, data in ArcGIS Pro can function similarly to Photoshop, merely in that it operates via layers, often with the capability to interact with other layers present. Point data exists in one layer and line data in another, often with another layer as a basemap displaying imagery. Layers are separate but can interact with each other, such as being able to highlight a point to see what lines interact with it. At a deeper level, ArcGIS Pro as a program is a powerful tool to analyze spatial relationships and manage data, features that will be of crucial importance as further data is added as the project progresses.

This project has worked primarily with the creation of point and line data as shapefiles (vector data) to place the movement of Xs in geographical context. Points indicate locations of permanent or temporary cemeteries, and sites of X origin. Points may be unique to an X and their movements or a location many individuals passed through. Lines indicate the movement of one X from one point to another. Lines indicate the segments of movements an X took, with additional data on each X in the attribute table. This phase of research employs a rudimentary use of ArcGIS Pro, but further iterations will seek to delve into the more complex data analysis functions it offers.

Chapter 3: Materials & Methods

Maps for this project were created using ArcGIS Pro, version 3.0.0. ArcGIS Pro is a professional geospatial analysis program developed by ESRI and first released in 2015. Intended for a wide range of uses in industry, academia, and beyond, it provides management, visualization, and analytical tools for geospatial data as well as other data visualization tools (Esri 2015). It allows for data integration from multiple spatial and non-spatial sources and formats to generate new datasets. For example, in this research, the data consisted of image files of historic cemetery maps and excel sheets containing X movement data derived from the X-Files (this is to say the digitized notes. Google Earth Pro version 7.3.4.8642 was also employed for peripheral use in locating lesser-known areas and assessing if multiple locations may have shared the same or similar names. All maps created for this project use the WGS 84 geographic reference coordinate system.

The process of mapping X movements consists of two stages: creating a point layer of locations of movements and creating a line tracking X movements through these points. Each point represents a location at least one X has been recovered from or moved through whereas each line creates segments from these points representing the total movements of one X. All points and line data are derived from spreadsheets tracking X movements that list location names associated with individual X numbers. The data is entirely textual at this stage, with stated coordinates being an exceedingly uncommon occurrence. The spreadsheets themselves are a condensed format of the documentation initially collected by the AGRS and other historic documents that noted the movements of individuals. Explicit geographical data is not typically present in the existing spreadsheets, hence the creation of points in the general vicinity of a location as an initial step in the process. The result is two layers, one of point features and one of line features.

Points are determined by current known geographical locations that best match the locations listed in the spreadsheets. Again, as the data is entirely textual, points must be created at the best approximation of the written location noted in the X movement spreadsheet. For towns or villages, this is an approximation of the center of the town. If locations are written with great enough specificity to place points in a more specific location, such as a particular neighborhood, the point is created in the approximate center of said location. For many locations this is a straightforward process, particularly in cases where the location is an established permanent cemetery. In other cases, the location may be listed as a town name, although in some cases towns have merged into other larger cities or are no longer a listed location entirely. The current spreadsheets preserved the wording of X movement documentation as it was originally written, which often means that original spelling and translation errors are still present. Some place names are listed in their German spelling or rough equivalent, for example Nuremberg being frequently noted as "Nurnburg". Polish city names were often listed by their German names such as Cychry, Poland as "Zicher". Some locations are noted by names or titles used during wartime such as "Hill 253, Belgium" or "Wild Sau" in reference to the Wilde Sau minefield near Hürtgen Forest, Germany, which requires additional historical research to locate. Others are missing portions of the location name, such as the "Lido Jipelle" or "Lido Remains Storage" - both referencing the Jupille area on the outskirts of Liege. In the process of locating these points correctly, the correct or modern spelling of the name is noted in the associated data within ArcGIS Pro as to facilitate finding the location in the future. After establishing their location, points are assigned a class ranging from Primary to Quaternary depending on how far removed the cemetery is from a permanent ABMC cemetery. Some Xs are noted as being from an Isolated Burial (IB) and are classed as Isolated. The Primary class consists only of permanent ABMC cemeteries, with each class after denoting the degree of separation the associated location has from a permanent cemetery.

Due to its search functions, the use of Google Earth Pro in tandem with ArcGIS Pro to locate and create point features proved useful in cases where the location was unlabeled or otherwise difficult to locate. It should be noted that Google Earth Pro utilizes a different projection than the one used for this project, resulting in imagery that appears distorted when compared to WGS 84 projections. However, as Google Earth Pro is used largely as a finding aid, this does not affect the points created in ArcGIS Pro. Once the area was located, each point was created using the Create Feature tool and data associated with each point was entered in via the Active Template window. Data for each point consists of six attributes: cemetery or location name, province, country, class (e.g., primary, secondary, tertiary), and X and Y coordinates generated from the creation of a point. Corrections to names as noted previously are made in parentheses after the original text in the cemetery or location name section. When useful, the symbology for location points can be changed to represent unique values and sorted by the Class attribute to visually display which points are of what class.

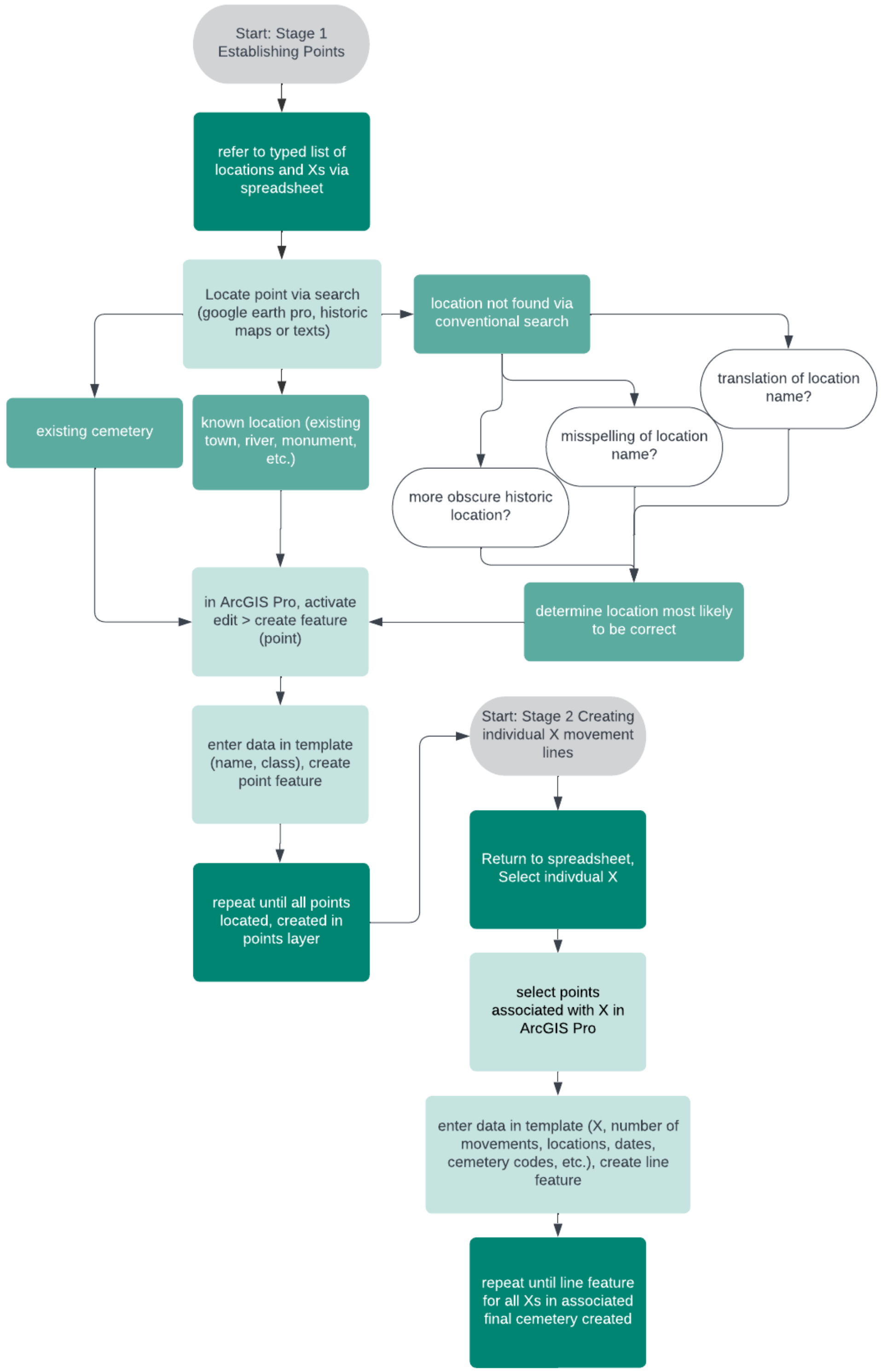


Figure 6. Flow diagram of mapping process

The relevant points tend to be unique to the cemetery of focus although there are occasional instances where points are shared by Xs that eventually track to separate final cemeteries. For this reason, layers with point features from prior cemeteries should be referenced during new point feature creation to ensure identical points are used for the same location regardless of final cemetery. As mapping progresses, this results in the creation of a master points layer that should be used for all future maps (shown in Figure 7). This is of particular importance when looking at a specific location's relationship to the Xs that passed through it and the potential contact they may have had. A misplaced point may result in missing an instance of overlap between two Xs. For the ease of data merging later, the same attribute table format is used in every point layer.

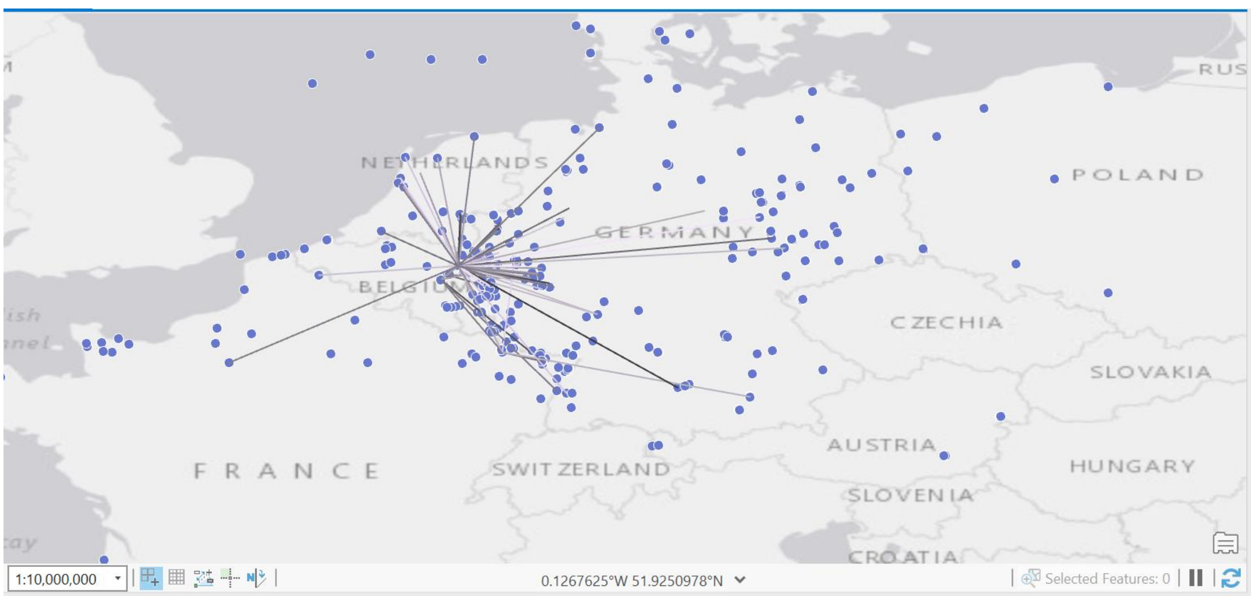


Figure 7. Map of X Movements into Margraten Cemetery, Shared Point Layer Represented in Blue, X movements in gray

Following satisfactory establishment of relevant points, the path of each X is drawn through the associated points in one segmented line displaying the general movements of the individual over time, leading to their final interment in a permanent cemetery. The creation of the points enables consistency in placement of line vertices and the ability to switch between viewing a point or line layer. Line vertices are placed directly on points, enabled by the "Snapping" setting. Use of this setting is key in maintaining locational consistency between the point and line layers as it reacts to features in other layers and "snaps" onto them.

For the purposes of this project, one segment is equivalent to one movement. Where this would be represented via a single line entry in the original data spreadsheets, it is represented as the segment between two vertices in ArcGIS Pro. The points corresponding to the locations associated with an individual X are selected from the attribute table, highlighting them on the map. Using the Create Feature tool, relevant data for the X and their movements is input via the Active Template window. The volume of data for each line varies depending on the number of movements an X progressed through. The data written into the line consists of the individual X number, number of movements, and, for each movement, the location (point) name, start or arrival date at the location, end or departure date at the location, cemetery code if applicable, geographic coordinate, and data fidelity if known. Space for incident type and number are present if said data is available. The result is a line feature tracing the approximate path of movement an individual X took, associated with locations, geographical coordinates, and relevant dates. This is shown via gray lines between blue location points in Figure 7. This process is repeated for each X to account for their individual movements. With both the completed point and line files brought into ArcGIS Pro, the shapefiles can be viewed together for the most complete

Regarding the accuracy of the points established and their precision (i.e. a point centered on a cemetery rather than over an exact grave within it) – At the current state the project is in, placement of points in the exact location an individual was recovered from is not necessary. This is due to the way we are utilizing GIS - as a visualization and data management tool. With more time and data dedicated to this project, precision will eventually be an aspect of the analysis that could be of use. At its current stage, the level of precision (i.e. city, cemetery, or general landmark) present so far is more than sufficient. Precision will also be dependent on the data available, which is an additional factor that would be assessed on a case-by-case basis. Regarding available data, other projects within the DPAA have employed methods to document locational accuracy, referred to as "fidelity". This may be something adapted into the project later as details such fidelity may factor into instances of commingling or assessing commingling risk.

The resulting product, a layer of known points and a layer of individual X movements, enables the use of the Attribute Table and Selection tools to examine the data. This may be to examine specific X movements originating from the same Isolated Burial or to examine an individual location and the relationship that may have with a specific X case. Xs can also be sorted by number of movements, associated dates, or cemetery code. This process is conducted for each of the permanent cemeteries managed by the American Battle Monuments Commission in the former European Theater. Once completed, files from all cemeteries can be compiled for a broader group of Xs and data to search. As eventual compilation of data is a significant consideration for the future of this project, consistency within the data and templates used to house it is important. Differences in shapefile template formats can result in the potential loss of data when two files are joined, posing an issue to the efficacy of the search function in the attribute table. As one desired end product is a shapefile for all X-associated points and X movement lines, this is achieved upon the completion of creating and saving these features. The larger goal of this project, to create a map with X location and movement data which may then be examined ArcGIS Pro (or any other program capable of viewing shapefiles), is simply achieved by using both shapefiles concurrently to investigate in-detail the movements of an X and their associated locations relative to other Xs, thereby allowing for identification of potential commingling instances.

Data

All documentation pertaining to an X, from the forms used by the AGRS to current documents detailing ongoing work, is kept in an X-File. The data used for this project are derived from historical documentation of unknown individuals and their movements across the European continent, as included in the X-Files. The original documents have been synthesized into several excel spreadsheets that were used as the basis for creating the movement maps in ArcGIS Pro. The data for the Netherlands American Cemetery represents 82 unidentified individuals. The data for the Ardennes American Cemetery and Memorial represents 368 individuals, half of the total number of unknown individuals interred there. Between the two cemeteries, there are roughly 455 unique locations at least one individual passed through on their way to a final permanent cemetery. A table of data used in the following case studies from the Ardennes American Cemetery and Netherlands American Cemetery is provided in Appendix A.

Table 3 below is a sample of the raw layout of X data in the spreadsheets provided for the project, with X-5441 as an example. The center column represents the start of a movement and righthand the end of one. Bolded text indicates the point of origin and bolded red text indicates the individual's final resting place. The first location is typically the rough location of death, in the case of X-5441, Hürtgen Forest, in Germany. The column to the right indicates that X-5441 moved from Hürtgen Forest in general to an Isolated Burial in Hürtgen Forest, Germany. The movement from Hürtgen Forest to an IB is considered one "movement".

Table 3. Example Movement Table, as provided by Defense POW MIA Accounting Agency files

X-5441	**Hürtgen Forest, Germany**	IB Hürtgen Forest, Germany
	IB Hürtgen Forest, Germany	SIP, Margraten, Holland
	SIP, Margraten, Holland	**USMC Neuville En Condroz**

From these data, points for each location and lines between them can be created to represent the movements X-5441 would have taken. This is not yet intended to be exactly geographically accurate to the exact route, as in the roads taken, method of transportation, etc., but to give an estimate of the areas various unidentified individuals congregated at, the frequency of those locations' use, and therefore a possible insight to the other individuals that may have commingled remains. A "short-list" of other individuals to check if the suspected identity of the individual is not supported by DNA or other identifying considerations. With further inclusion of the dates individuals were at each location, this list may be further narrowed down.

Chapter 4: Results

The end product of the methods described above is a map of both all the movements and all the locations as they relate to unknown individuals being transported from the battlefield to a final cemetery. Mapping the data via ArcGIS Pro allows for more interaction with the data visualization of the data, with the ability to investigate specific questions based on what part of the data is selected. This relies primarily on the attribute query and select functions, the most rudimentary methods of examining data in ArcGIS Pro. This is intentional, as the functionality of a tool is only as good as its accessibility. Avoidance of more complicated measures to investigate connections between data serves to make the map useful to any researcher who has access to the file, not necessarily requiring intense familiarity with ArcGIS Pro. Further steps in this project may eventually result in more involved processes to examine specific intersections of data with greater specificity, but this basic user-friendly functionality of the data would still be retained.

As discussed in the Methods section, the attribute table consists of several separate pieces of information related to each X individual. Certainly, selecting an individual X by their number would be a way to see their movements and associated points. Further, the entire suite of X individuals may be searched by other associated data, such as total number of movements, shared routes, or shared locations. All three are factors that have the potential to affect a general risk of commingling. The number of movements an individual goes through potentially increases the geographical distance they cover, the places they move through, and the number of people their remains interact with, adding further opportunity for mistakes to take place, remains to be lost or damaged, or any number of other factors. However, this does require some interaction taking place - for example, we can likely rule out commingling between two individuals who proceeded along entirely different movement paths and ended at different final locations. However, if two individuals shared a route, went into the same remains storage facility, were re-examined in the same lab, and then later finally interred, there is a greater potential that commingling or an accidental ID switch-up could have occurred. Being able to visualize these possibilities and create a shortlist of individuals to cross-reference based on shared routes, locations, or other connections may enable a more efficient reaction when an initial identification turns out to be incorrect. The following figures and descriptions are examples of how this could be conducted using a random selection of Xs from the Netherlands American Cemetery. Further investigation of the relationships between Xs and movements will be discussed in separate examples from the Netherlands American Cemetery and Ardennes American Cemetery.

Figure 8 shows a search by an individual X number and how it displays in the ArcGIS Pro Map of Margraten Cemetery. In this example, X-09086's movements can be seen from an Isolated Burial in Walderscheid, Germany, to an AGRS Facility in Greisheim, Germany, and lastly to Margraten Cemetery. In this case, no other Xs share this exact route or originate from the same point. For this reason, we can infer that X-09086 is less likely to be commingled with other Xs.

Figure 9 displays a search based on a single location, in this case Neuville-en-Condroz. This selection highlights all Xs that passed through Neuville-en-Condroz and ended their movement in Margraten Cemetery. In this example, if the transition from Neuville-en-Condroz to Margraten Cemetery was suspected as a possible movement during which the remains of X-8516 were commingled with other unidentified individuals, this search would display a "shortlist" of individuals that were at the same location and therefore potentially more likely to be commingled with the remains in question. In this case, this reduces the number of Xs in question to three, X-8289, X-6756, and X-4435.

Figure 10 displays a search by number of movements, in this case any X with fewer than three movements. If number of movements can be considered as number of potential interactions with other Xs, sorting by number of movements may serve to highlight cases that may be more or less likely to be commingled.

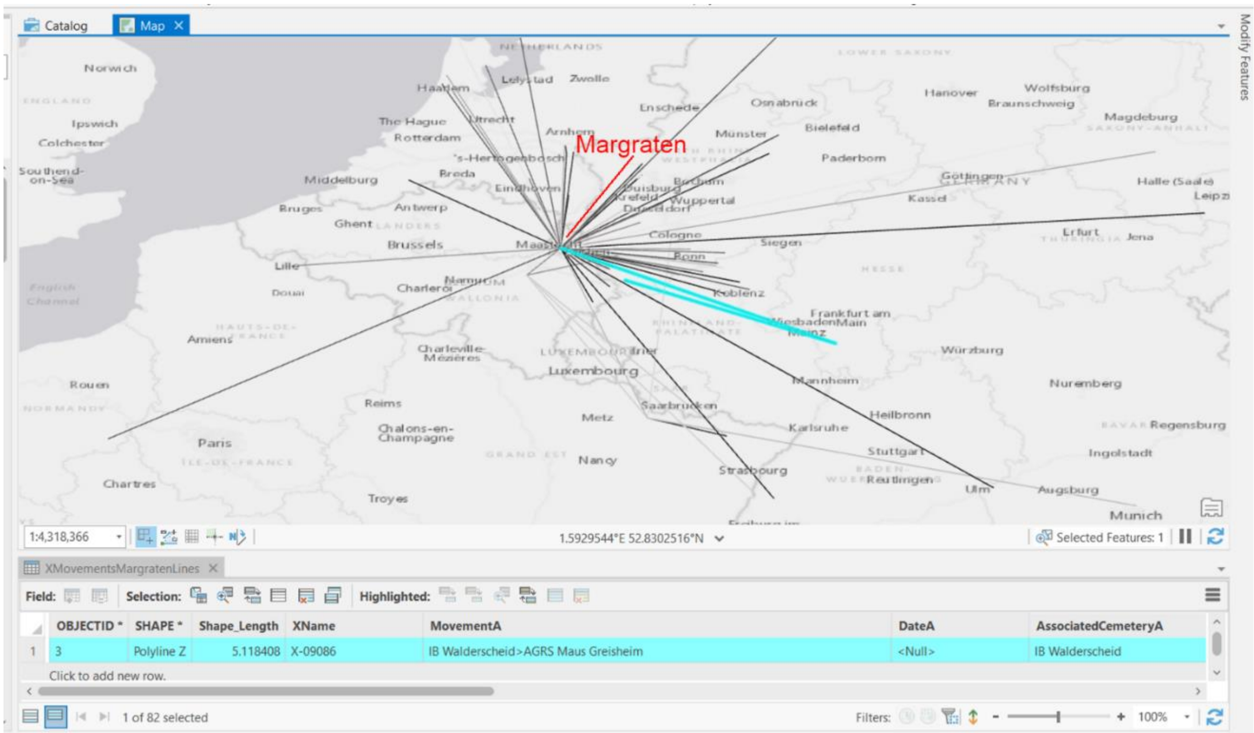


Figure 8. ArcGIS Pro map of movements into Margraten Cemetery, displaying a search by individual X file. (Esri, 2021)

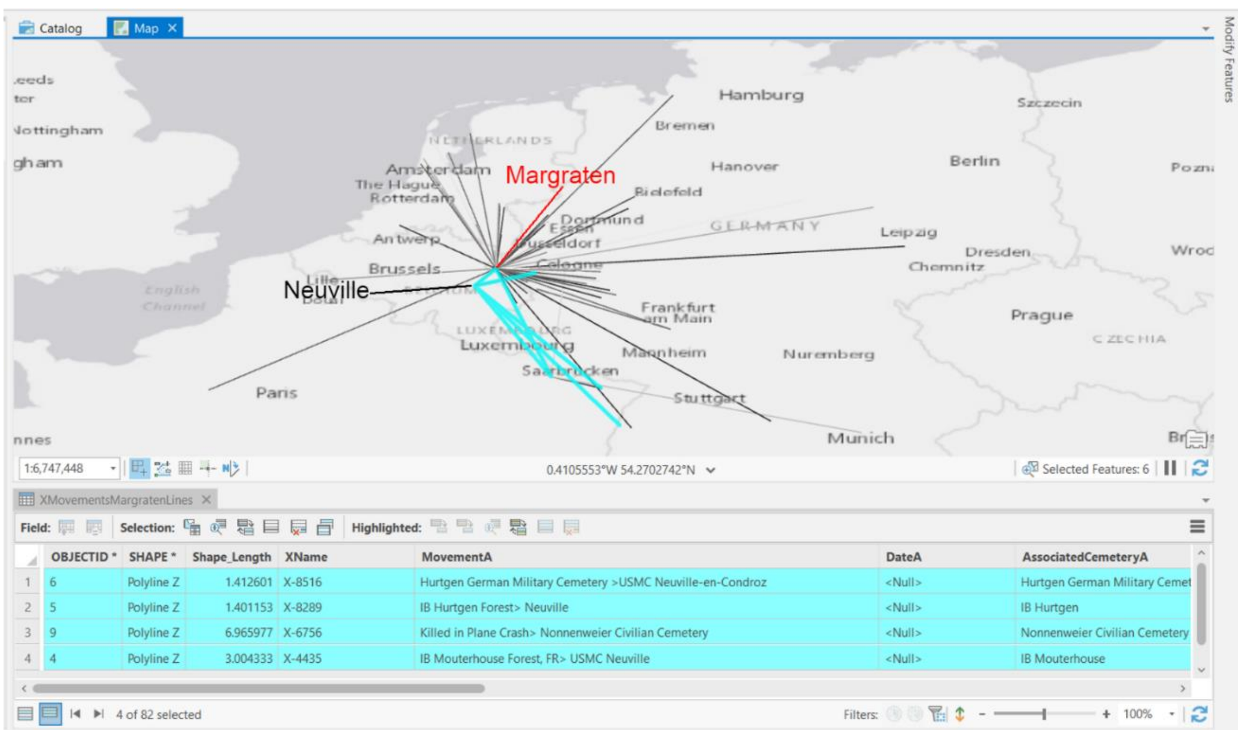


Figure 9. ArcGIS Pro map of movements into Margraten cemetery displaying a search by a single location (Esri, 2021)

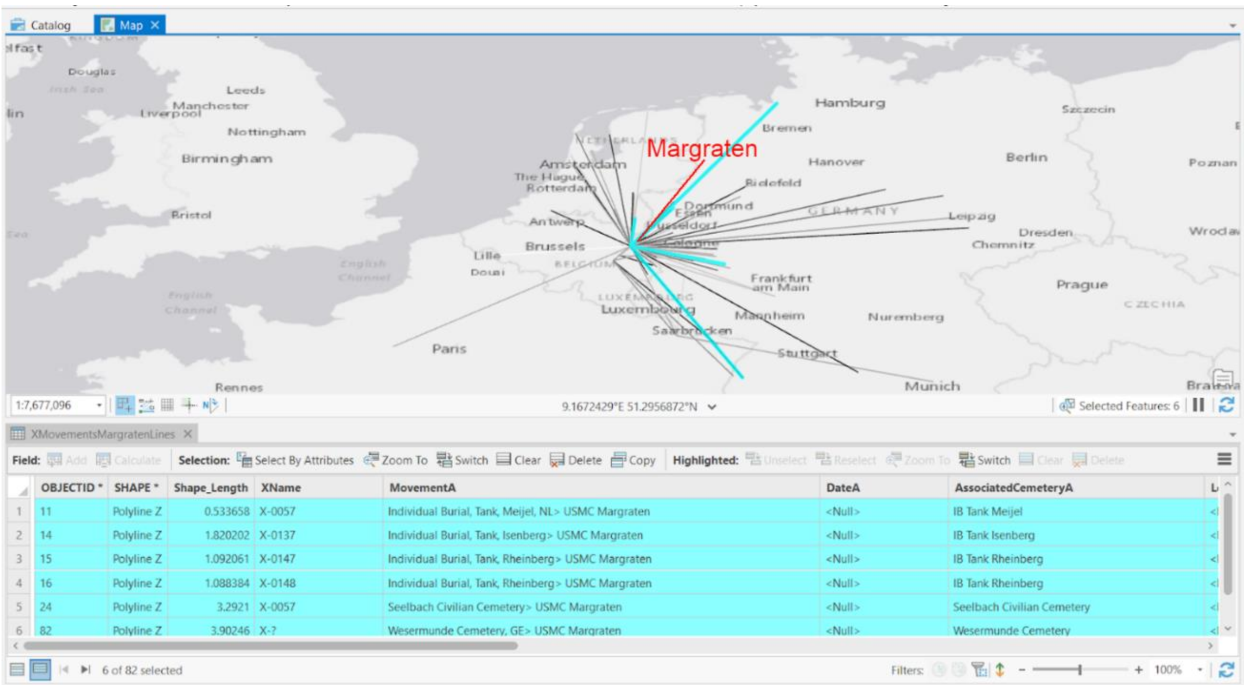


Figure 10. ArcGIS Pro map of movements into Margraten Cemetery displaying a search by number of movements (3>) (Esri, 2021)

Case Study 1: Margraten Cemetery

The NAC (historically and henceforth referred to as "Margraten") was first opened near the village of Margraten, Netherlands, in November 1944 (Steere 1951). A map of its approximate original extent is shown in Figure 11. It saw the most use by the Ninth Army, also receiving burials from members of the 82nd and 101st Airborne divisions. The remains of members of the 82nd and 101st Airborne were recovered from emergency battlefield burials elsewhere in the Netherlands, from operation Market Garden (Steere 1951). The Margraten Cemetery was operated by platoons from the 611th Graves Registration company via the Ninth Army, followed by the 605th, 608th, and 3046th Graves Registration companies. By 1945 the Margraten Cemetery would be operated by only two of the 611th Graves Registration company's platoons with assistance from two Quartermaster Service companies and had expanded (Figure 12) to nearly twice its original extent (Steere 1951). Post-war, management of the NAC and further burials would be conducted by the First Zone of the AGRC (Steere & Boardman, 1957). The Margraten Cemetery functioned as an SIP until its closeout in 1947, when further duties were routed to the CIP at the AAC. The Margraten Cemetery was transferred to the ABMC on December 15th, 1948, although some AGRC activities continued as necessary on unidentified individuals (Steere & Boardman, 1957). Upon its transfer, it was briefly closed and remains were disinterred and subsequently reinterred in the layout designed by architectural firm Coolidge, Shepley, Bulfinch, and Abbott (Steere 1951; Steere & Boardman, 1957). The AGRC requested all identification work on individuals interred at the NAC be complete by the 15th of July 1949, prior to the closeout of AGRC activities in Europe. Margraten was dedicated in 1960, and officially named the Netherlands American Cemetery (ABMC, 2022a). Its current layout is shown in Figure 14.

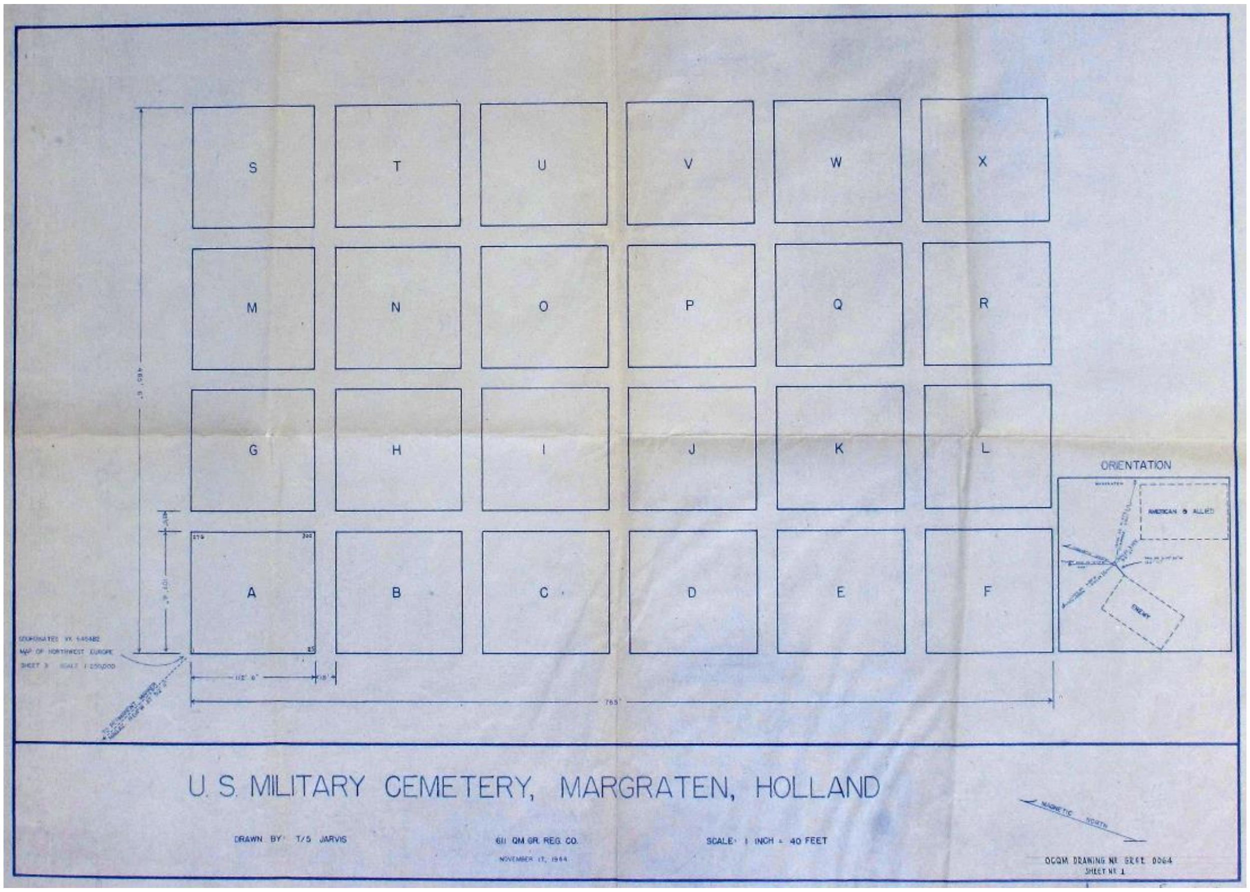


Figure 11. 1944 Map of Margraten Cemetery

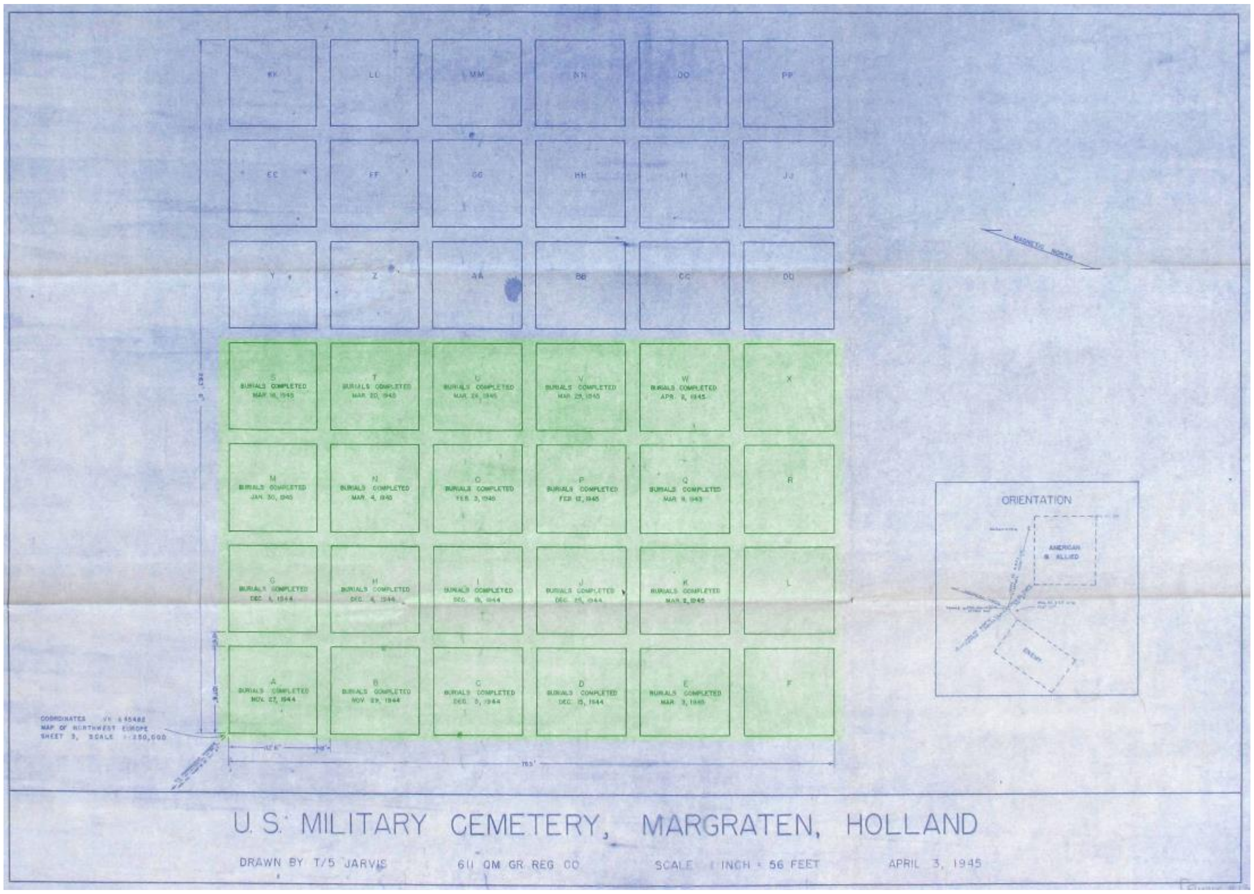


Figure 12. 1945 Map of Margraten Cemetery, original extent shown in green

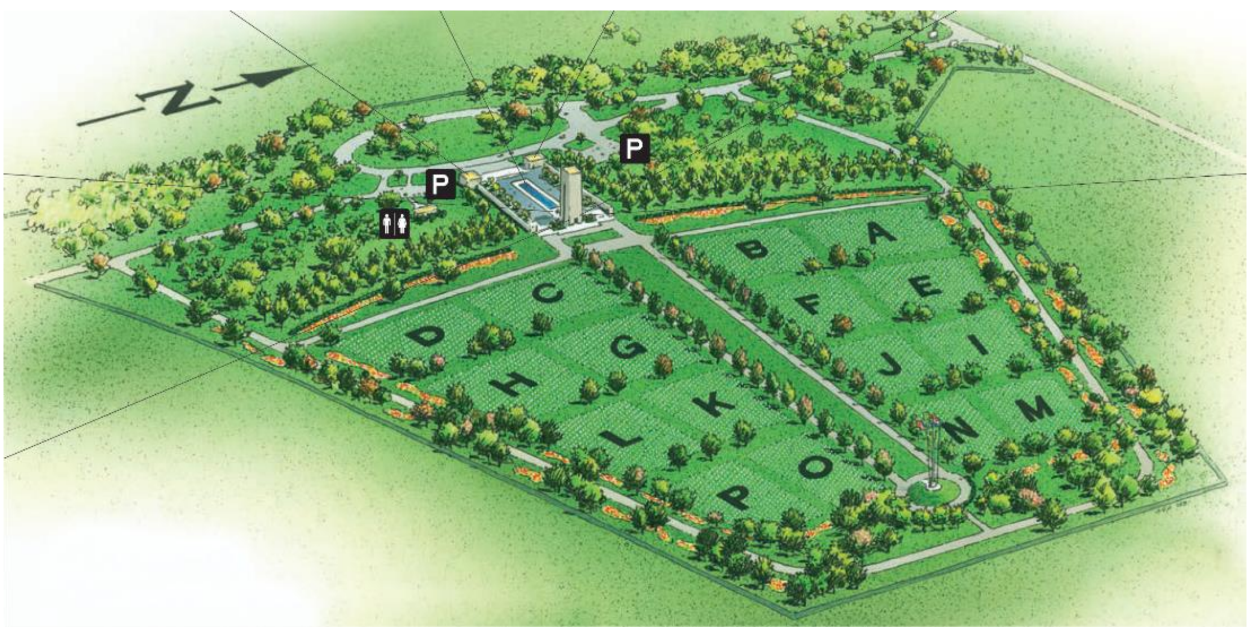


Figure 13. Modern Layout of the NAC (Margraten) (ABMC, 2018b)

This section will discuss both the potential interpretations of commingling risk between X-0183, X-6068, X-6756, and X-13037 due to their shared paths out of the St. Avold cemetery as well as X-6756's increased risk of commingling with other Xs due to their stop at the Ardennes American Cemetery (AAC) during its time as both a cemetery and CIP. X-0183, X-6068, X-6756, and X-13037 were selected as examples due to their central point of convergence (St. Avold), representative variation in routes, and variation in taphonomic effects that may contribute to or detract from comingling. These interpretations are speculative and operate under the assumption that these individuals are the only ones passing through St. Avold at the time. This may not have been the case, as many others also passed through St. Avold or even remained there, or for the fact that the Xs may not have passed through the same route at the same time. However, until further temporal data are available to indicate otherwise, this case study will utilize these four Xs and operate under this hypothetical, isolated travel situation. Further, the lack of specific temporal data introduces a greater degree of uncertainty of these potential points of overlap. With the introduction of temporal data, a potential list of other Xs that may have crossed paths with an X in question may be narrowed down significantly.

Margraten Cemetery, later known as the NAC, saw a total of 82 Xs move from temporary cemeteries and burials into final graves, often moving through several locations in the process (see Figure 14). In this example, X-0183, X-6068, X-6756, and X-13037 began in separate locations on their way to the NAC. In this process, they all passed through the St. Avold temporary cemetery in Metz, France. Although St. Avold would become one of the permanent ABMC cemeteries in Europe, these individuals passed through the cemetery at a point when St. Avold was not yet taking permanent burials. Additionally, although all individuals ended up at NAC, their paths may have resulted in some degree of commingling prior to their arrival. Particularly as three of the four Xs (X-0183, X-6756, and X-13037) were killed in separate aircraft crashes (Figure 15), taphonomic effects resulting from their manner of death may have made their remains particularly difficult to tell apart. As aircraft crashes of this era often result in highly fragmented remains and a variety of taphonomic effects, it cannot be relied upon that they could be easily distinguished via size, articulation, or other factors that may have aided in sorting and identification of other remains. Further, X-6576 also passed through Neuville-en-Condroz, another large cemetery at the time and the location of a CIP, introducing more opportunities for commingling with additional individuals that may have been transported, stored, or analyzed there at the same time.

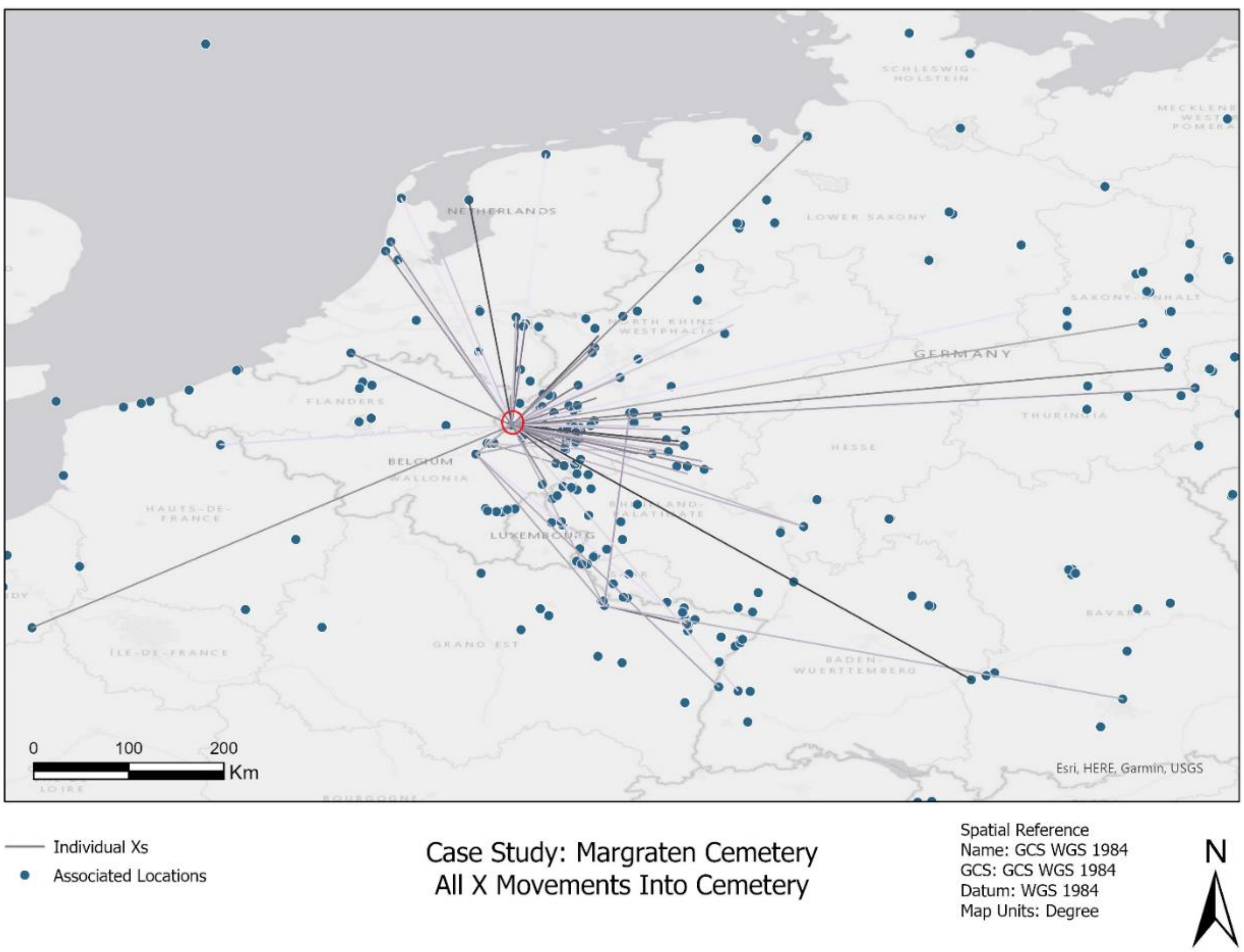


Figure 14. Movements of all 82 Xs into the NAC (Margraten Cemetery, circled) (Esri, 2021)

Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear Delete Copy

	FID	Shape *	XName	MovementA	DateA	MovementB	DateB	MovementC
1	0	Polyline	X-0183	Killed_in_Plane_Crash,_...	<Null>	IB_Lindenthal>USMC_S...	<Null>	St_Avold>Margraten
2	1	Polyline	X-6068	IB_Reipertswiller_Bas_Ri...	<Null>	IB_Reipertswiller_Bas_R...	<Null>	St_Avold>Margraten
3	2	Polyline	X-6756	Killed_in_Plane_Crash>...	<Null>	Nonnenweier_Civilian_...	<Null>	USMC_Neuville-en-Co...
4	3	Polyline	X-13037	Killed_in_Plane_Crash,_...		Hochmutting_Civilian_...		USMC_St_Avold>_USM...

Click to add new row.

Figure 15. attribute table for X-0183, X-6068, X-6756, and X-13037 noting recovery location – killed in aircraft crash, and isolated burial.

X-0183, X-6068, X-6756, and X-13037 were all recovered from separate locations in Germany and France. X-0183 was recovered from an isolated burial after an aircraft crash near Lindenthal, Germany, X-6756 from a aircraft crash site near Nonnenweier, Germany, and X-13037 from a aircraft crash near Hochmutting, Germany. X-6068 was recovered from an isolated burial site near Reipertswiller, France. All four Xs were brought to St. Avold cemetery, although X-6756 initially moved through the AAC, possibly the CIP at that location, prior to their arrival at St. Avold. X-0183, X-6068, and X-13037 went through a total of two movements from their location of recovery to the NAC. By comparison, X-6756 took a total of three movements due to their time at the AAC (Figure 16). As discussed previously, any movement is an opportunity for commingling as movements occurred in groups. By movements alone, we can predict that there is a higher likelihood that X-6756 was commingled with other individuals than X-0183, X-6068, and X-13037.

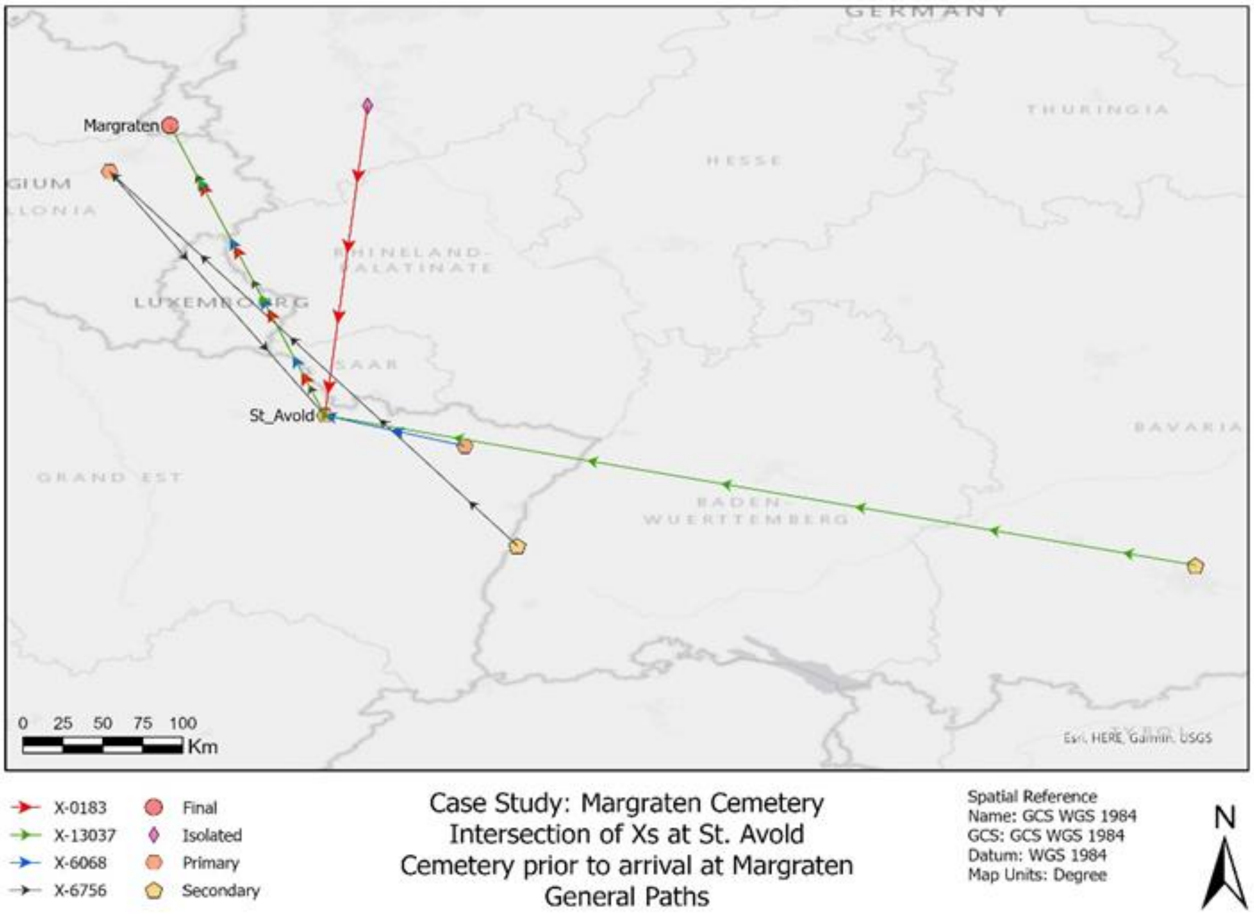


Figure 16. Map of general paths and locations of X-0183, X-6068, X-6756, and X-13037 (Esri, 2021)

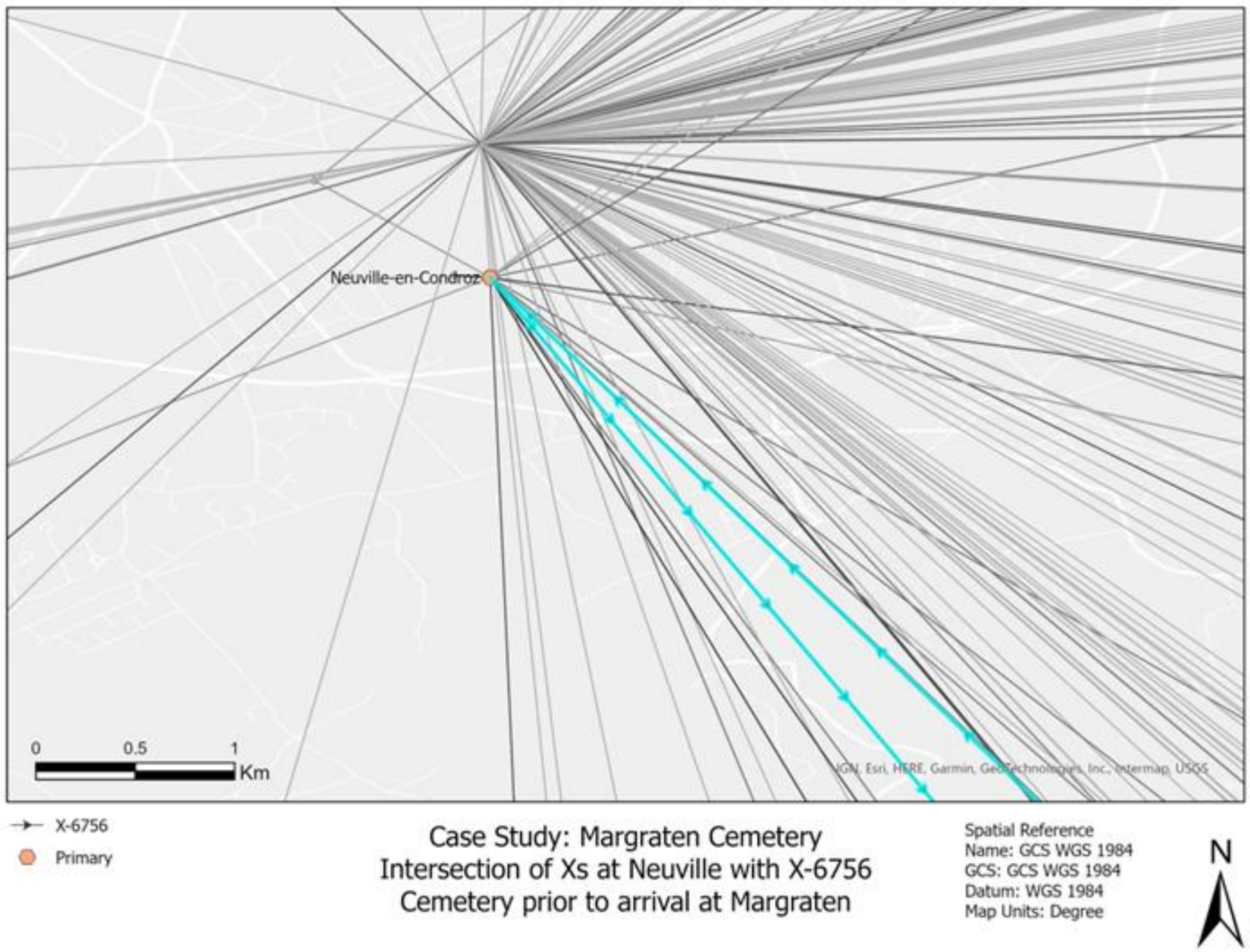


Figure 17. X-6756 moving in and out of the AAC (Neuville-en-Condroz), in relation to other Xs with no final movement to the NAC (Margraten). (Esri, 2021)

X-6576, due to their transportation and contact with other Xs to a more significant degree than the other three in this example, may have a higher degree of commingling potential due to the increased opportunity. Additionally, this potential may be higher due to X-6576 passing through Neuville-en-Condroz (AAC), a location that saw significant traffic. As noted previously in the History of Recovery and Identification in the European Theater of Operations section above, the AAC was also the site of a CIP that was used as another intermediary point between exhumation and reinterment, both for attempts at identification and for storage of identified remains. X-6756 is shown in Figure 17 with lines indicating other Xs moving through the AAC and AAC CIP, highlighting the number of other individuals that may have come into contact with X-6756.

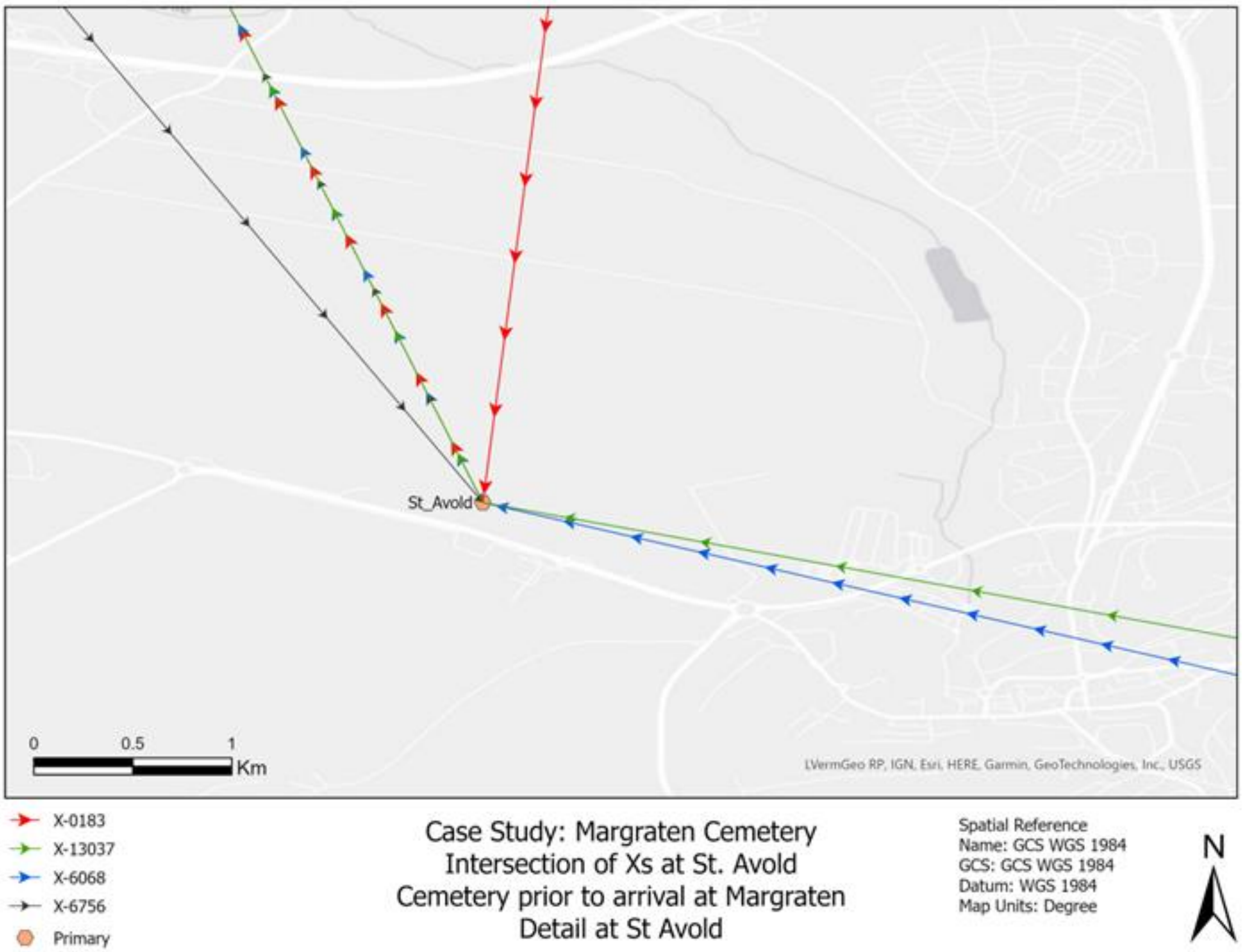


Figure 18. Movement of Xs into St. Avold and out on the same route toward the NAC (Esri, 2021)

Eventually, all Xs were moved into St. Avold and back out to the NAC (Figure 18). From this, we can speculate that X-6068 may be the least likely to be commingled with the other three Xs in this case, as those killed in aircraft crashes would likely have more distinguishing taphonomic effects such as fragmentation and even amount of remains recoverable (Palmiotto et al. 2020). Particularly if X-6068 was a ground loss, methods such as articulation and pair matching of skeletal elements may still be viable for distinguishing between individuals. X-0183 and X-13037 were both killed in aircraft crashes but went through the same number of movements as X-6068. This would make them more difficult to become commingled with X-6068, but possibly more likely to be commingled with each other, or other Xs also killed in aircraft crashes such as X-6756. Fragmentation of remains adds another layer of difficulty in distinguishing between individuals. Lastly, as X-6756 went through the greatest number of movements accompanied by a death in an aircraft crash and transportation with two other Xs from similar incidents, they stand to have the greatest likelihood of commingling of the four. With further data on specific transportation procedures between cemeteries and temporal information on the periods each X was at each location, we may be able to further narrow down lists of individuals that may be commingled with the X in question, even with a much larger data set.

Case Study: 2 Neuville Cemetery

The AAC (historically and henceforth referred to as "Neuville") was established in December 1944 to address challenges posed in collection of remains from the "bulge" area in eastern Belgium (Steere, 1951). It was primarily used by the Advanced Section of the Communications Zone, European Theater of Operations (ADSEC) and First army (Steere, 1951). An early layout of the cemetery is shown in Figure 19. Neuville is notable for being the only cemetery set up by ADSEC's Graves Registration personnel (Steere, 1951). It became one of three central collection points at the time (along with Grand Faily cemetery and Henri-Chapelle cemetery), introducing the use of a midway collection point, removing the need for each collecting team to travel the entire way to Neuville. Instead, multiple collecting teams met at a single point closer to their points of origin and offloaded remains to another fleet of vehicles going from the collection point to the cemetery. This enabled collecting teams to return to conduct further sweeps faster, increasing likelihood of retrieving remains sooner (Steere 1951). Through its use as a central collection point, Neuville additionally became a CIP. Post-war, management of Neuville and further burials was conducted by the First Zone of the AGRC (Steere & Boardman, 1957). Neuville would continue its role as a central location for the AGRC, remaining an active CIP under the AGRC until 1950 (Steere & Boardman, 1957). In addition to its burials, Neuville would continue to house a CIP, morgue, and at times a Records and Administrative Section office, etc. As noted previously, the staff at the SIP at Margraten were transferred to Neuville after the SIP was closed in the summer of 1947 (Steere & Boardman, 1957). Neuville was temporarily closed in September of 1948 for disinterment and reinterment of remains in its modern layout (Figure 20) (Steere & Boardman, 1957). It was reopened in March 1949 once burials were finalized (Steere & Boardman, 1957). Neuville was the last cemetery turned over to the ABMC, transferring to their control in June 1951 (Steere & Boardman, 1957). It was dedicated in 1960 (ABMC, 2022b)

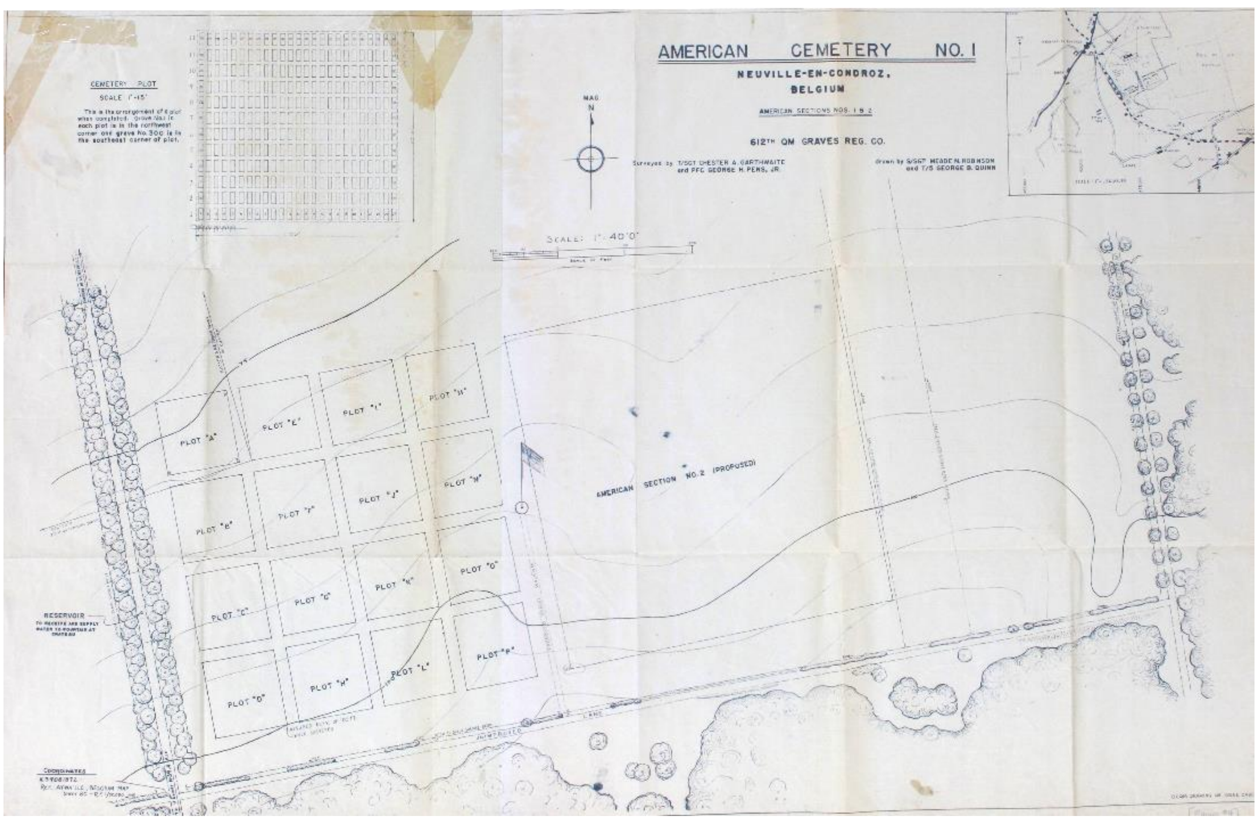


Figure 19. Historic Map of Neuville Cemetery

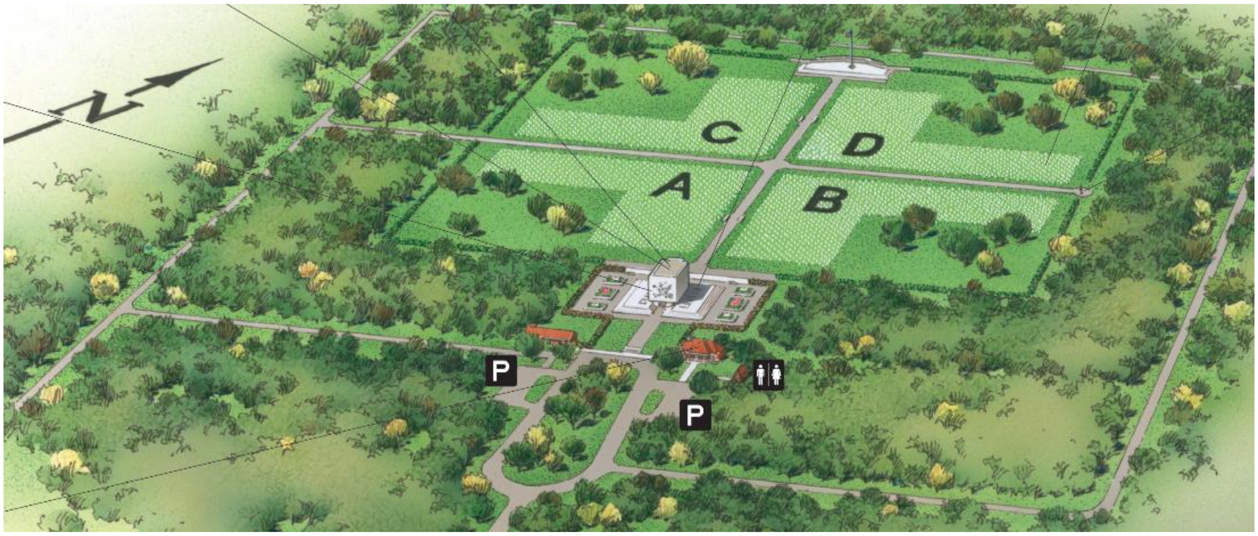


Figure 20. Modern Layout of the Ardennes American Cemetery (Neuville) (ABMC, 2018a)

Neuville, later the Ardennes American Cemetery (AAC), saw a total of 736 Xs move from various temporary cemeteries and burials into final graves. This section will focus on a subset of those individuals, looking at 56 Xs originating from the Hürtgen Forest, the site of a drawn-out battle and numerous casualties. From here, the focus will be narrowed to individuals who were transferred to the NAC, a total of 9 Xs, and lastly toward three Xs that took the same path from an isolated burial to the NAC SIP, and lastly to the AAC. This will then be followed by a brief discussion of potential crossovers between the previous case study's Xs (X-0183, X-6068, X-6756, and X-13037) and the specific three that passed through the NAC on their way to the AAC, X-5441, X-5442, and X-5450.

Figure 21 displays the locations associated with all seven Xs and their general relationship to each other geographically. Figure 22 shows the movements of all Xs from the Hürtgen forest area to the AAC with the three Xs of focus shown in red. Figure 23 displays the movements of X-5441, X-5442, and X-5450 from Isolated Burials in the Hürtgen Forest area to the SIP at the NAC, and lastly to the AAC. Note that this map only displays one line between these points as, according to currently accessible documentation, all three took the exact same path. As in the prior example, this case study will operate under the hypothetical that X-5441, X-5442, and X-5450 are the sole Xs at their point of origin and on their exact routes. Their paths overlap with X-0183, X-6068, X-6756, and X-13037 from the previous case study, converging at both Margraten and Neuville. This is shown in Figure 24, Figure 25, and Figure 26.

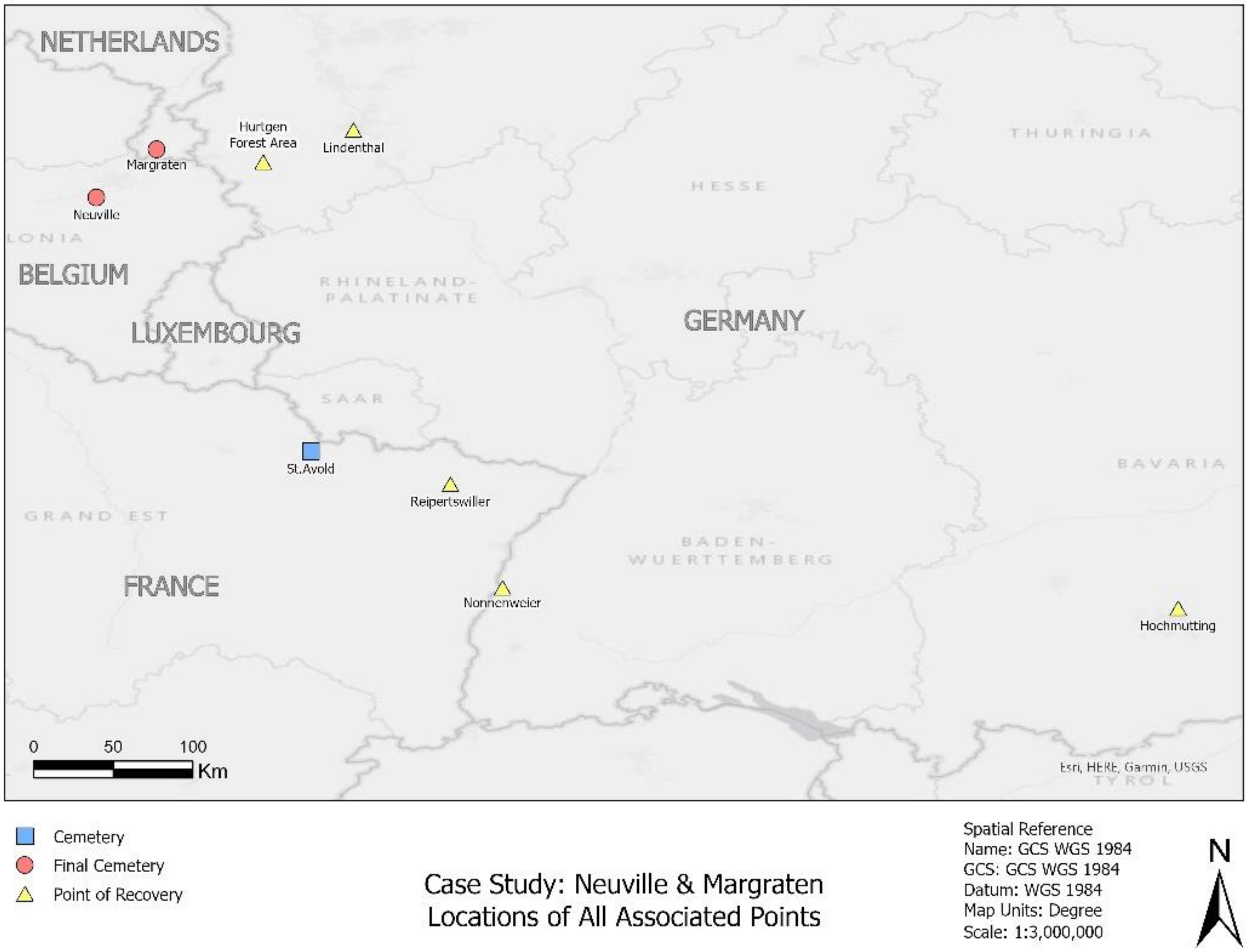


Figure 21. All Case Study X Associated Points (Esri, 2021)

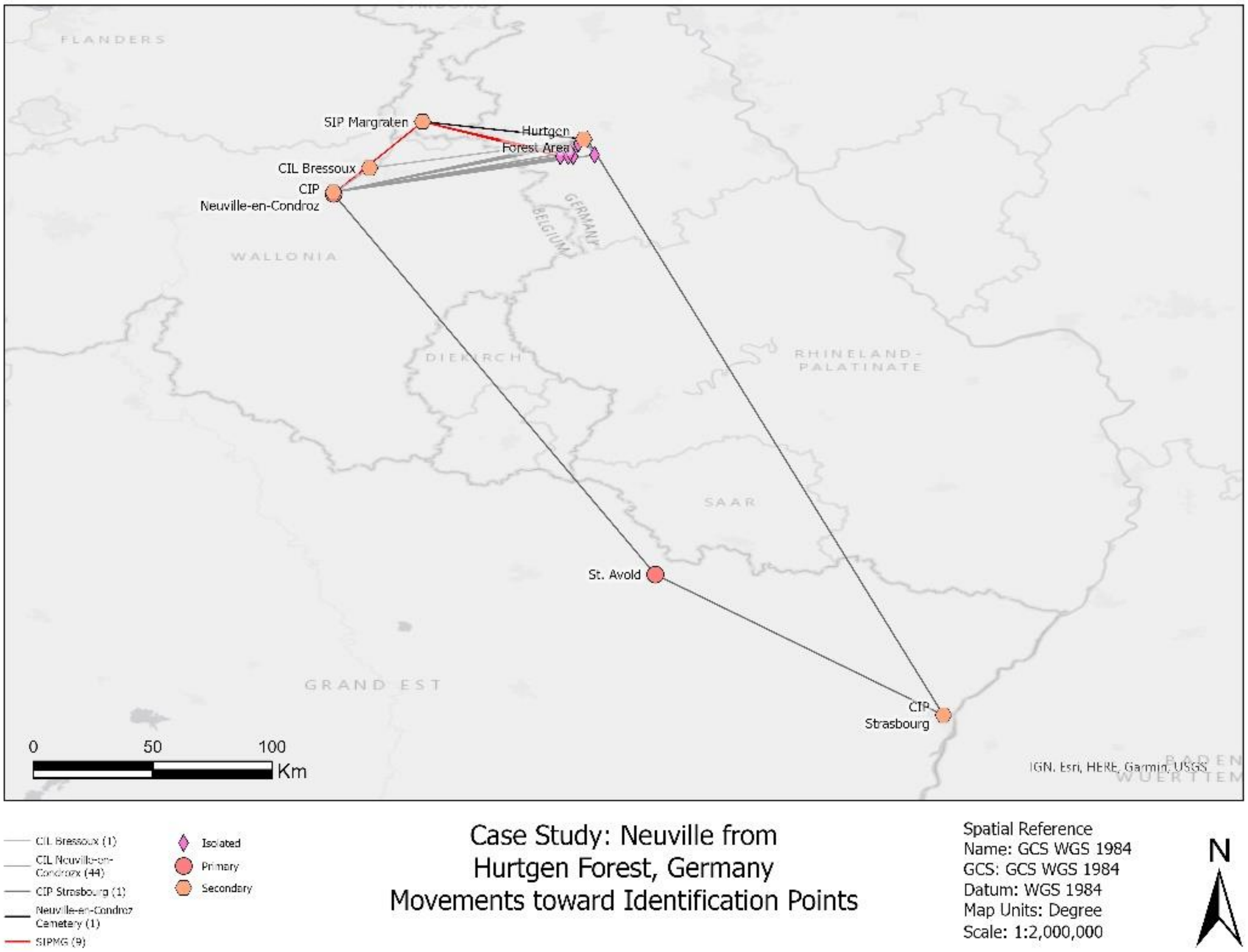


Figure 22. All Hürtgen Forest Area X Movements to Neuville (Esri, 2021)

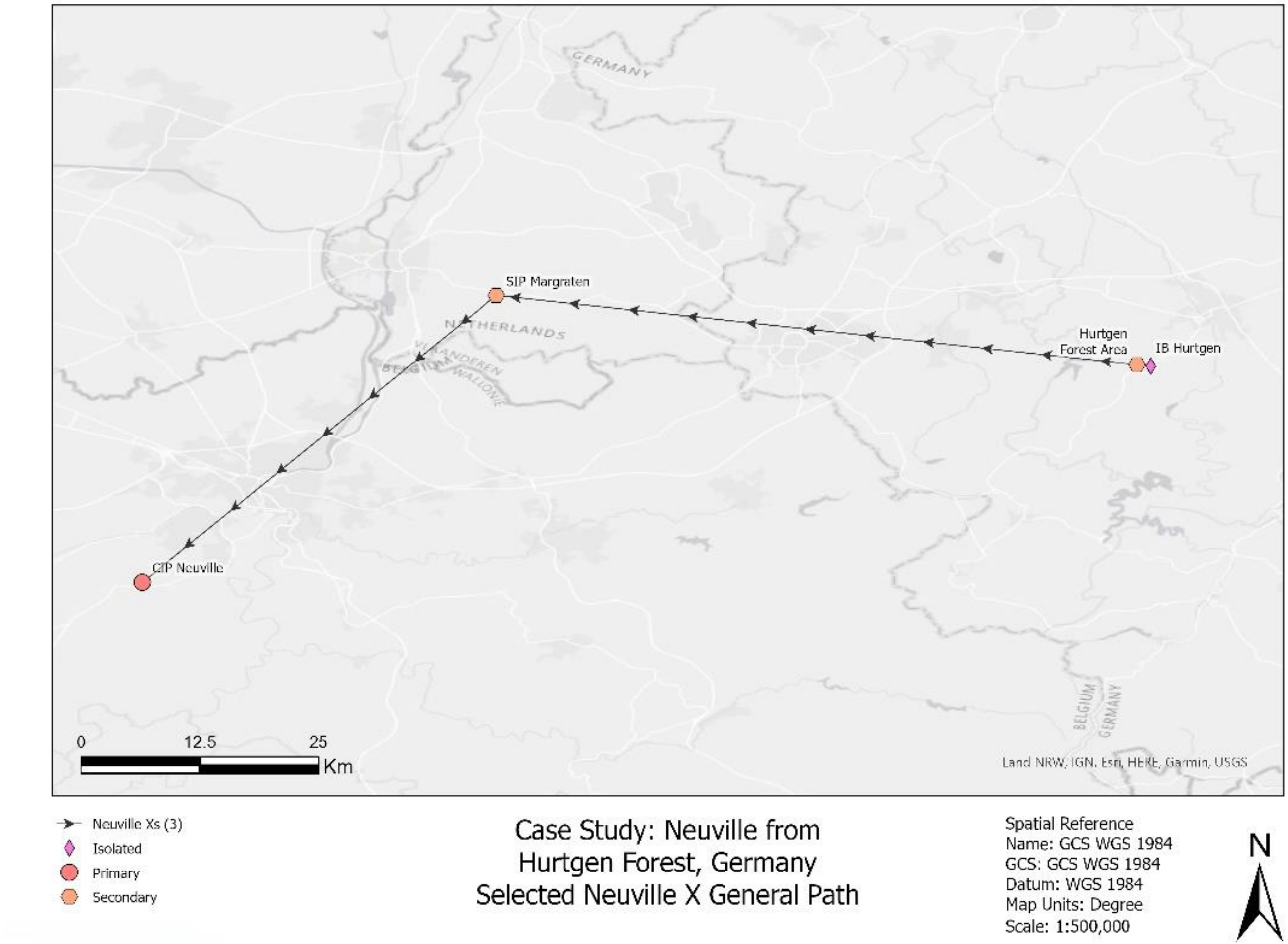


Figure 23. Movement of X-5441, X-5442, and X-5450 from Hürtgen Forest Area to Neuville (Esri, 2021)

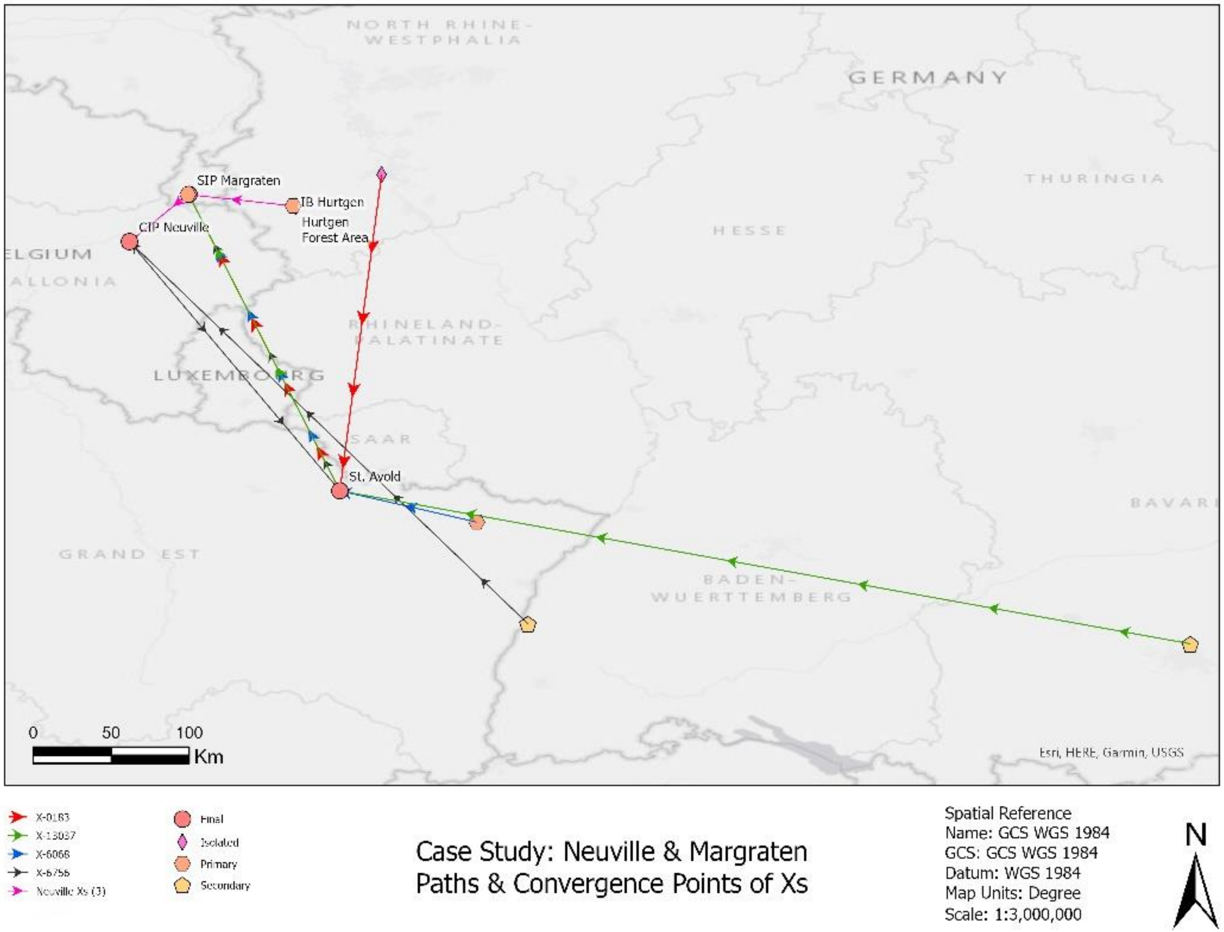


Figure 24. All Paths from X-0183, X-6068, X-6756, X-13037, X-5441, X-5442, and X-5450 (Esri, 2021)

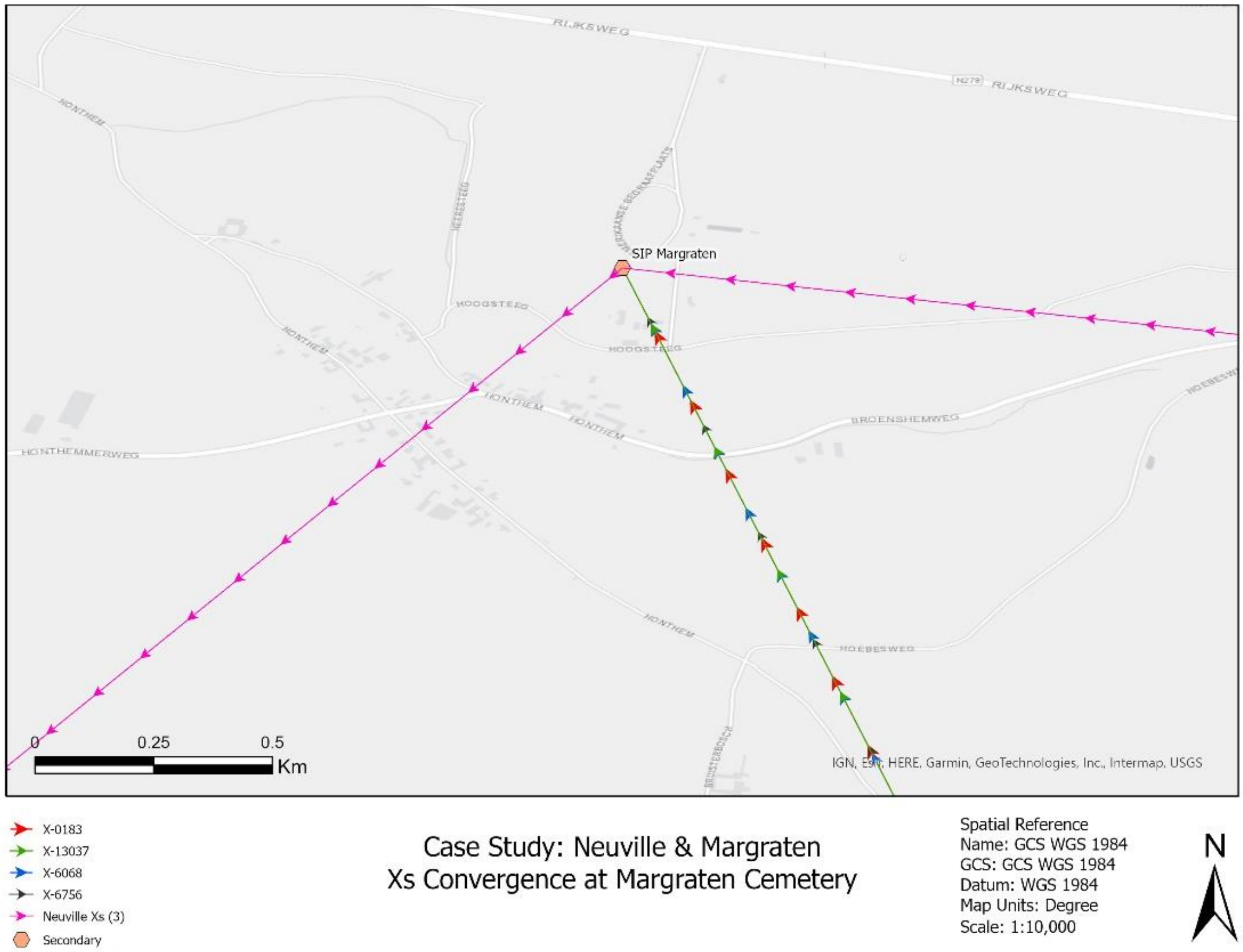


Figure 25. X Movement Convergence at Margraten (Esri, 2021)

Figure 26. X Movement Convergence at Neuville (Esri, 2021)

X-5441, X-5442, and X-5450 are all noted as having gone from the general Hürtgen Forest area to Isolated Burials, then passing through the NAC SIP specifically, and lastly transferred to the AAC. If these three Xs were the only individuals making these specific movements, commingling could only occur between them. However, to further explore this hypothetical series of events, the movements of X-0183, X-6068, X-6756, and X-13037 and the points at which they intersect X-5441, X-5442, and X-5450 will be examined in-depth and commingling opportunities highlighted and discussed. Potential convergences and therefore potential commingling instances could have taken place at either the NAC or AAC, and in an extreme scenario even at St. Avold.

Assuming the point of convergence is at the NAC or the NAC SIP (shown in Figure 25), X-5441, X-5442, and X-5450 may have crossed paths with all four previous Xs, X-0183, X-6068, X-6756, and X-13037. However, as will be discussed further, it is possible that X-5441, X-5442, and X-5450 may have only crossed paths with X-0183, X-6068, and X-13037 due to X-6756 taking a slightly different route. In this scenario, X-5441, X-5442, and X-5450 would reach the NAC at the end of their first movement, with X-0183, X-6068, X-6756, and X-13037 reaching the NAC at the end of their second (third for X-6756) movements. Provided they arrived and were processed at a similar time, remains from X-0183, X-6068, X-6756, and X-13037 could theoretically be commingled with X-5441, X-5442, and X-5450, eventually moving out of their original assemblage of remains and into the AAC during the Hürtgen Xs' second movement. This is to say that remains from X-0183, X-6068, X-6756, and X-13037 may have been transported to the AAC not via their own series of movements but along with another group's. However, if X-6756 did not undergo the movement to the NAC at the same time as the other three Xs and was perhaps even still at the AAC, they may have avoided commingling with either group entirely.

Assuming the point of convergence is at the AAC *and* at St. Avold but not the NAC, the source of commingling would have to be X-6756, who, once joining X-0183, X-6068, and X-13037 could have commingled further. The importance of temporal data becomes particularly apparent when examining the movements of X-5441, X-5442, and X-5450 in relation to X-6756's movements. X-6756's movements take them to both the AAC and the NAC, with a return to St. Avold between the movements. X-6756 cannot (officially) be at all locations at once. Therefore, contact with X-6756 could only have occurred at one location. Which location this would be depends upon the segment of movements X-6756 or X-5441, X-5442, and X-5450 were undergoing at the same time. For instance, if X-5441, X-5442, and X-5450's first movement to the NAC SIP occurred in tandem with X-6756's third movement and final destination, the NAC, contact occurring at the AAC can likely be ruled out. Inversely, if X-5441, X-5442, and X-5450 were on their second and final movement from the NAC to the AAC while X-6756 was on their initial movement from Nonnenweier to the AAC then contact with X-5441, X-5442, and X-5450 could only have occurred at the AAC, ruling out commingling with X-6756 at the NAC. There is no scenario where contact could have occurred at both the NAC and AAC. Depending on the duration X-6756 remained at the AAC before moving to St. Avold also influences considerations of commingling with X-0183, X-6068, and X-13037 as although they made the same final movement, they may not have occurred contemporaneously.

Each hypothetical results in a different scenario in which different Xs are more or less likely to have commingled with each other. X-6756 continues to be an example of how minor variation in routes, whether via an extra movement or non-concurrent transportation, can isolate or compound opportunities for commingling. A difference in timing on specific movements makes the difference between being able to conclude X-5441, X-5442, and X-5450 are potentially commingled with X-0183, X-6068, X-6756, and X-13037 or with X-6756 alone. There is, of course, a final scenario where no commingling occurred between the NAC group and AAC group. The NAC group may have been undergoing their second movement before the AAC group had even departed St. Avold. If this is the case, there may not have been any clear opportunities for commingling between the seven Xs.

Chapter 5: Discussion

The case studies shown rely on a curated dataset to illustrate the functions of the maps at their current stage. The added nuance of temporal data would make the use of a larger dataset much more practical, returning a narrower range of connections than is currently possible. Although the availability of this information may vary from X to X, the X-Files associated with each likely still hold further data that can be applied to existing mapped X movements. Further consideration of loss incident types or methods of transportation for each movement are additional variables that should be taken into account. Additional variables such as the potential of commingling at point of recovery and the volume of remains passing through each location at a given point in time may also prove to be important factors in establishing or ruling out commingling at these locations. Considerations should also be taken into account regarding the actions of the AGRS and AGRC. As noted regarding X-0183, X-6068, X-6756, and X-13037, analysts may have been able to distinguish between individuals to some degree due to the trauma represented in the remains. Further, the extent of trauma and quantity of remains present would have affected what methods of addressing commingling would have been viable.

Although the maps appear static, the structure of the maps, features, and associated attribute tables in ArcGIS Pro allows for more dynamic interaction with the data. It is important to consider that the maps track numerous movements occurring over time. Each X is a moving target. Inclusion of temporal data for when movements take place in relation to each other will play a significant role in introducing more nuanced interpretations of results from searching these points of convergence between Xs. The examples above rely on a curated dataset to illustrate the functions of the maps at their current stage. The added nuance of temporal data would make the use of a larger dataset much more practical, returning a narrower range of connections than is currently possible.

Additionally, the usefulness of a tool can be severely limited by the barrier of entry to its use. In employing the methodology in this project, we have intentionally created a tool that is accessible with a basic level of training in ArcGIS Pro. Learning the basic skills to at the very least search through the attribute tables/databases created in this project could be accomplished in a day or less, allowing any researcher to put it to use. At its core, this is one of the most important aspects of what this tool should be: functional. The basic functions of this tool should exist beyond the fingers of GIS specialists. Although more detailed and intensive functions would certainly be appropriate and are anticipated in further work on the project, this should not mean that there is loss of usefulness or functionality in the beginning stages.

Chapter 6: Conclusions and Future Directions

At the current stage of the project, my colleague Mason McKinney (2022) and I have addressed data from three permanent cemeteries managed by the ABMC across Europe. (See McKinney, 2022 For an additional case study of X movements into the Sicily-Rome American Military Cemetery.) Further work on this project seeks to process data from the remaining ten cemeteries in a similar fashion, eventually combining the individual cemeteries into an interactive map representing all movements from unidentified individuals from temporary to permanent cemeteries across the European continent. Further methodological improvements may also arise from continued effort on this project as there are many functions and tools of ArcGIS Pro that have not yet been applied. It should be stressed that this is a *foundation* to a geospatial approach to addressing commingling between Xs. Further additions must be made until it can be considered a complete representation of movements in the European Theater of Operations, but through the case studies prior its potential utility should be evident. At the very least, this project should help establish a general protocol for how this process may be replicated, in such a way that it may even be applied to other mass casualty events and commingling. If unidentified individuals are assigned some individuating title and their movements are tracked, this method may be applied.

Inclusion of identified individuals should also be considered as a likely future addition. The structure of the data would allow for an identified individual's name to be used in place of an X number in the attribute table, allowing for seamless integration of known individuals with unknown. It is not uncommon for some skeletal elements to be lost over time to taphonomic effects or otherwise and remains are often incomplete. For this reason, we cannot rule out that some remains of identified individuals are comingled with those unidentified. Further, transportation may have taken place with already identified individuals, resulting in potential commingling between the unidentified and the identified. This is to say that often, remains are incomplete even when positively identified.

Professionals in the field and laboratory do their utmost to ensure that the remains they recover and analyze are as complete as possible and representative of a single individual. Despite the best efforts put forward, sometimes remains are unidentifiable or unrecoverable. This is not to say that every identification is partially incorrect or that identified individuals are missing portions of their remains that were otherwise recoverable. However, it is to raise the possibility that in the event that tests are run and results for identification are not consistent with what historical records would suggest, commingling of remains is a possible reason. Therefore, examination of which individuals are most likely to have come into contact with the individual in question may serve a significant role in collecting and identifying the remains accurately.

ArcGIS Pro provides many tools that may be applicable to this project. The addition of functions in the data to track frequency of use for specific routes from locations and investigate potential relationships between Xs is one additional way comingling risk could be examined. The non-spatial functions of ArcGIS Pro have not come into play at this stage of the project but could be of significant benefit as well. The original movement charts from prior researchers and "social networking software" charts created by the S&R project could likely be replicated via the ArcGIS Insights data visualization functions while still maintaining the additional geographic data they have due to this project. In effect it creates both a spatial and non-spatial tool for examining the relationships between Xs, locations, routes, and movements within the same program, retaining data that was lacking in initial movement charts. Additionally, ESRI, the makers of ArcGIS Pro, have produced GIS software for over two decades to date. Their software is an integral part of spatial analysis for a vast number of organizations, institutions, and governments and likely offers more stability and longevity of data created within ArcGIS Pro. This is to say that concerns for issues with data preservation into the future as seen with some graphics from the S&R project can be somewhat assuaged by the widespread usage and longevity of both ESRI and open-source GIS software. So long as the shapefiles are kept on a storage system, there will likely be a form of ESRI or open-source software that can open them.

As further research continues, the project seeks to add cemetery data down to plot, row, and grave (PRG) specificity. This would be accomplished by the addition of polygons in a grid over cemeteries, accounting for the PRG designation and past and present occupants of each grave to allow for easier reference and cross examination of individuals in adjacent graves. This would need to be implemented not only for the modern layout of the ABMC cemeteries but also for their historic layouts, as well as any temporary cemeteries with sufficient historic documentation, particularly dated maps. Further, inclusion of identified individuals should also be strongly considered for the PRG grid system. Although Xs were intended to be in separate sections, we cannot eliminate the possibility that there were circumstances that necessitated deviation from standard procedure. Further data on PRG placement is likely still accessible through the X-Files and Individual Deceased Personnel Files (IDPFs). This would need to be extracted and added to the existing X movement data, as well as data on movements of identified individuals.

Temporal data will continue to be highly relevant to accuracy and meaningful interpretations of the data. The times during which different individuals occupied each grave should be as much a consideration as when they underwent movements. PRG specificity would not provide the desired results without knowing if the adjacent graves being cross referenced were occupied at the same time. Without temporal data, unnecessary effort may be put toward investigating leads on other individuals who were no longer present to commingle with the X in question, or had not arrived at the destination yet in the first place.

Additionally, multiple versions of TM 10-630 or FM 10-63 were issued throughout the period the AGRC was active during wartime. Each version offered changes and alterations from the prior text that were then to be adhered to. What exactly these changes were is currently undocumented outside of the texts themselves. If these changes happened to be regarding burial procedure, there may be a temporal aspect affecting identification probability due to the version of TM or FM in use at the time. This is to say that different versions may have better or worse instructions for burial that affect identification outcomes. This in turn may have a larger effect on understanding additional factors that may be in the way of identification on an individual case basis.

There is some detail in Steere's 1951 text on the AGRC wartime activities or in Steere & Boardman's 1957 text regarding the post-war efforts of the AGRC regarding the general function, storage methods, or facilities of the established CIPs or SIPs. Further, transportation methods for remains were noted to have varied through time and depending on the route to a cemetery, SIP, or CIP. Although Steere & Boardman note that railroad systems were a key component of transportation, it is unclear how this transportation took place on a micro (rather than macro) level. Were these individuals contained in blankets or mattress covers, as instructed by FM 10-63 (U.S. War Department, 1945, p. 19), or casketed? Supply issues were noted throughout the AGRS' early years, but not to what degree this may have affected transportation efficiency. These questions are unanswered at the time of writing and therefore require further investigation regarding a potential effect on comingling. Further examination of historic texts regarding the transportation process was out of the scope of this project but may be merited to establish what procedures were put in place when, and how this may affect our interpretation of how likely it is that comingling-in-transport took place.

Ultimately, time, volume of effort, and funds are limited resources in the mission to identify the U.S.' remaining missing servicemembers. The creation of tools that require fewer resources and can ease more intensive identification methods is a pursuit highly relevant to our efficiency in identification. No matter how noble the cause, DNA tests take time and cost money. If establishment of a functional geospatial resource can help to make a list of tests to be done shorter, aid in investigating questions about comingling potential, or examination of specific factors that affect identification, it will serve its purpose in helping the mission. Further, it may be extrapolated to mass-casualty scenarios beyond the identification of U.S. war dead and serve a greater humanitarian effort.

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VVxjKG6GRoCj1EQAvD_BwE%3AG%3As&s_kwcid=AL%218948%213%21516819963768%21p%21%21g%21%21arcgis+platform&_bk=arcgis+platform&_bt=516819963768&_bm=p&_bn=g&_bg=118193649581&gclsrc=aw.ds

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Appendix A: Case Study Data

Table 4. Case Study Data

Cemetery	X	Movement: Starting Location	Movement: Ending Location
Neuville (AAC)	X-5441	**Hürtgen Forest, Germany**	IB Hürtgen Forest, Germany
		IB Hürtgen Forest, Germany	SIP, Margraten, Holland
		SIP, Margraten, Holland	**USMC Neuville En Condroz**
Neuville (AAC)	X-5442	**Hürtgen Forest, Germany**	IB Hürtgen Forest, Germany
		IB Hürtgen Forest, Germany	SIP, Margraten, Holland
		SIP, Margraten, Holland	**USMC Neuville En Condroz**
Neuville (AAC)	X-5450	**Hürtgen Forest, Germany**	IB Hürtgen Forest, Germany
		IB Hürtgen Forest, Germany	SIP, Margraten, Holland
		SIP, Margraten, Holland	**USMC Neuville En Condroz**
Margraten (NAC)	X-0183	**KIPC Lindenthal, Germany**	IB Lindenthal, Germany
		IB Lindenthal, Germany	USMC St. Avold, France
		USMC St. Avold, France	**USMC Margraten, Holland**
Margraten (NAC)	X-6068	**Reipertswiller Bas Rhin, France**	IB Reipertswiller Bas Rhin, France
		IB Reipertswiller Bas Rhin, France	USMC St. Avold, France
		USMC St. Avold, France	**USMC Margraten, Holland**
Margraten (NAC)	X-6756	**KIPC Nonnenweier, Germany**	Nonnenweier Civ Cem, Germany
		Nonnenweier Civ Cem, Germany	USMC Neuville-en-Condroz, Belgium
		USMC Neuville-en-Condroz, Belgium	USMC St. Avold, France
		USMC St. Avold, France	**USMC Margraten, Holland**
Margraten (NAC)	X-13037	**KIPC Hochmutting, Germany**	Hochmutting Civ Cem, Germany
		Hochmutting Civ Cem, Germany	USMC St. Avold, France
		USMC St. Avold, France	**USMC Margraten, Holland**

Appendix B: Additional Historic Documentation

WD QMC Form 1089
1 September 1944
(GRS No. 2)

HEADQUARTERS GRAVES REGISTRATION SERVICE, Q.M.C.

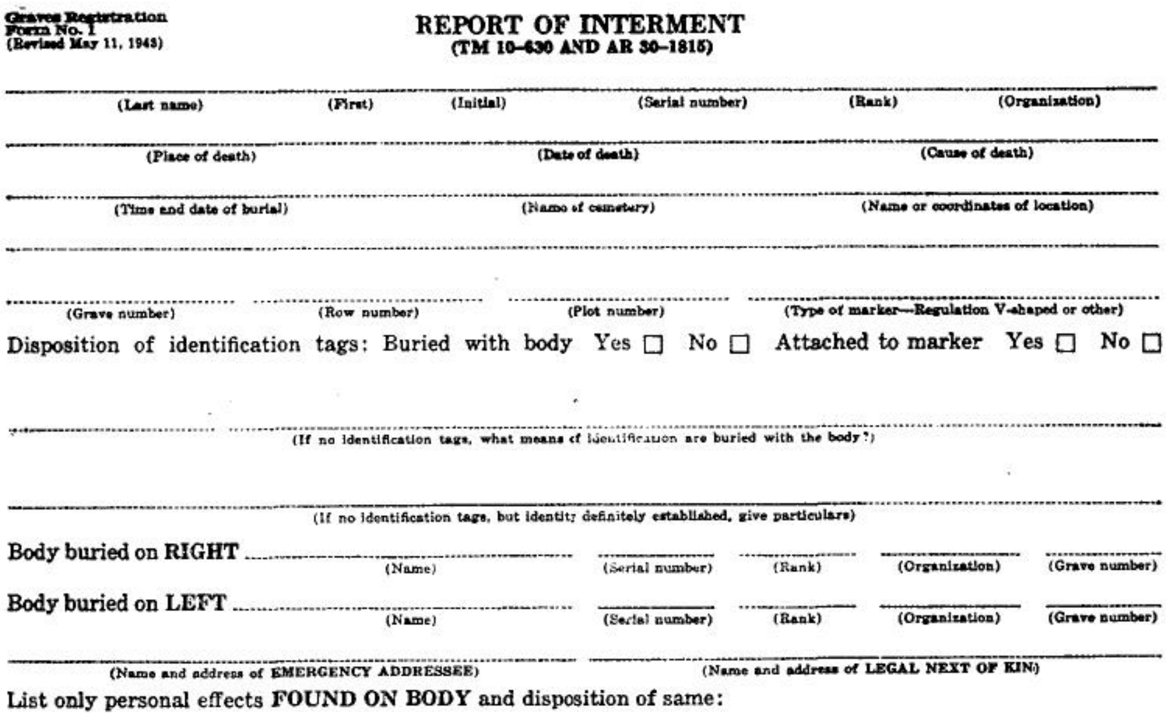
WEEKLY REPORT OF BURIALS RECORDED

(To be submitted to Quartermaster General)
(Par. 32 TM 10-630)

No. ______________ Date ____________________ 19___

NAME	SOLDIERS NO.	RANK	ORGANIZATION	DATE OF BURIAL			CEMETERY

Figure 27. Blank Weekly Report of Burials Recorded Form (US War Department, 1945)


Graves Registration
Form No. 1
(Revised May 11, 1943)

REPORT OF INTERMENT
(TM 10-630 AND AR 30-1815)

(Last name) (First) (Initial) (Serial number) (Rank) (Organization)

(Place of death) (Date of death) (Cause of death)

(Time and date of burial) (Name of cemetery) (Name or coordinates of location)

(Grave number) (Row number) (Plot number) (Type of marker—Regulation V-shaped or other)

Disposition of identification tags: Buried with body Yes ☐ No ☐ Attached to marker Yes ☐ No ☐

(If no identification tags, what means of identification are buried with the body?)

(If no identification tags, but identity definitely established, give particulars)

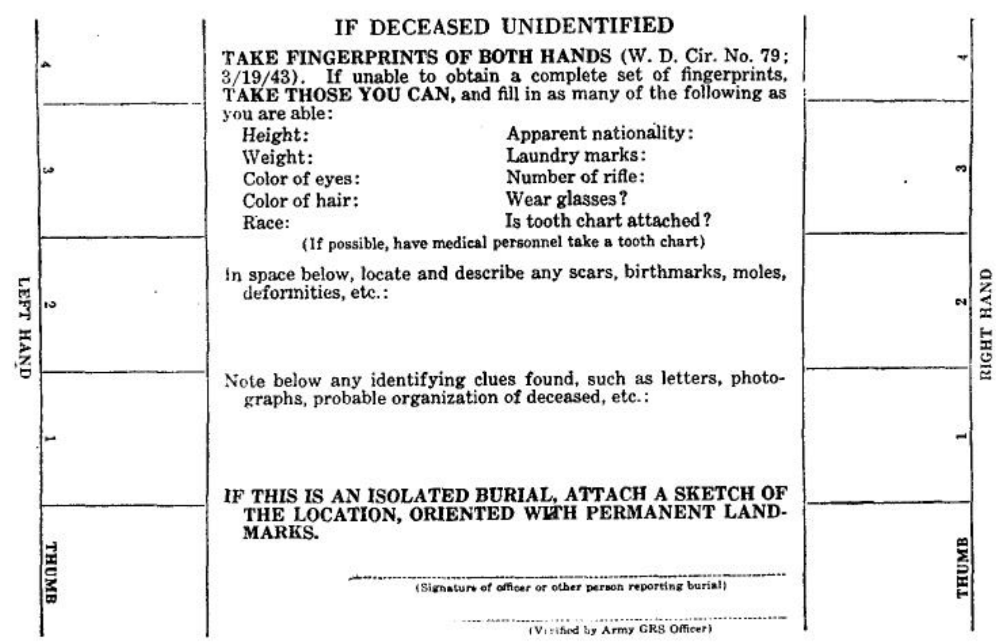
Body buried on RIGHT .... (Name) (Serial number) (Rank) (Organization) (Grave number)

Body buried on LEFT .... (Name) (Serial number) (Rank) (Organization) (Grave number)

(Name and address of EMERGENCY ADDRESSEE) (Name and address of LEGAL NEXT OF KIN)

List only personal effects FOUND ON BODY and disposition of same:

Figure 28. Blank Report of Interment Form, Front (US War Department, 1945)


IF DECEASED UNIDENTIFIED

TAKE FINGERPRINTS OF BOTH HANDS (W. D. Cir. No. 79; 3/19/43). If unable to obtain a complete set of fingerprints, TAKE THOSE YOU CAN, and fill in as many of the following as you are able:

Height: Apparent nationality:
Weight: Laundry marks:
Color of eyes: Number of rifle:
Color of hair: Wear glasses?
Race: Is tooth chart attached?
(If possible, have medical personnel take a tooth chart)

In space below, locate and describe any scars, birthmarks, moles, deformities, etc.:

Note below any identifying clues found, such as letters, photographs, probable organization of deceased, etc.:

IF THIS IS AN ISOLATED BURIAL, ATTACH A SKETCH OF THE LOCATION, ORIENTED WITH PERMANENT LANDMARKS.

(Signature of officer or other person reporting burial)

(Verified by Army GRS Officer)

LEFT HAND: 4, 3, 2, 1, THUMB
RIGHT HAND: 4, 3, 2, 1, THUMB

Figure 29. Blank Report of Interment Form, Back. (US War Department, 1945)

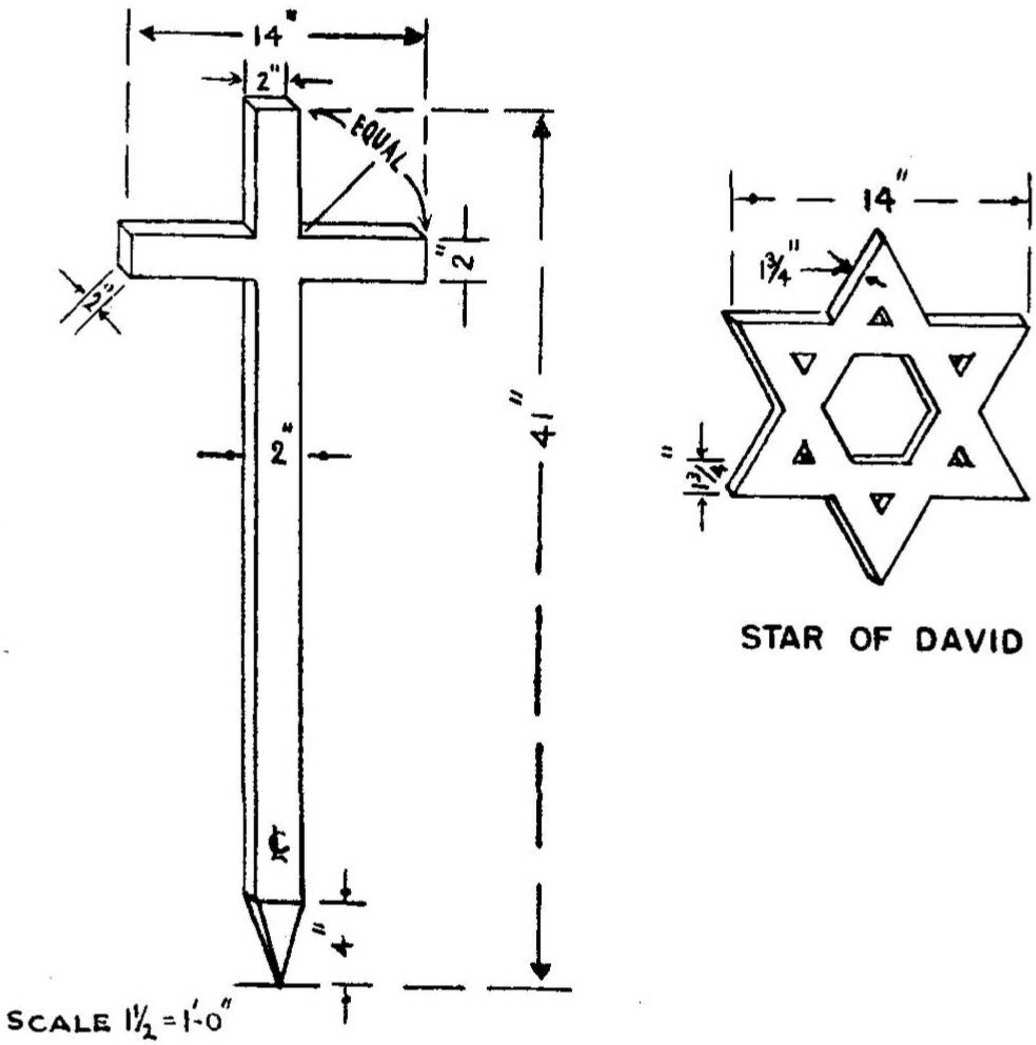


Figure 30. Schematics for Cross & Star of David Grave Markers Used in Temporary Cemeteries (US War Department, 1945)

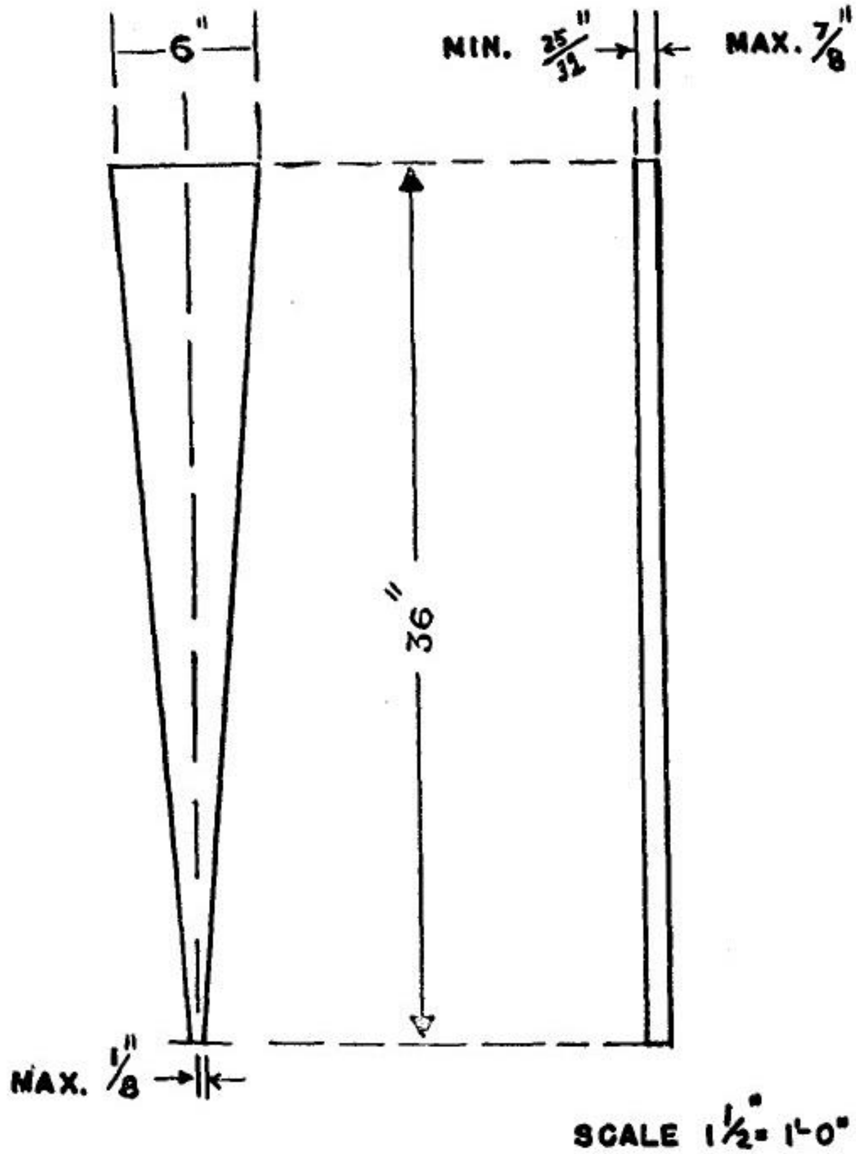


Figure 31. Schematic for Temporary Name Peg Grave Marker for Use in Temporary Cemeteries (US War Department, 1945)