Theater-Level Logistics: A Structured Comparison of Allied Port Operations in Northern Europe During World War II

A Monograph

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Abstract

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This monograph argues that, at the theater-level, logistical planners must anticipate forward movement. This research uses three elements of operational art—operational reach, tempo, and culmination—to assess a concept of anticipation of movement. Using historical case studies, this research examines the concept of anticipation in terms of planning and execution during two phases of port openings during the Allied advance in the ETO during WWII. The first phase covers the port opening in France from the invasion of Normandy (6 June 1944) to the opening of Antwerp (28 Nov 1944). The second phase picks up from the opening of Antwerp to the end of the conflict in Europe (7 May 1945). The goal of this examination of anticipation is to better understand the effects of logistical planners' ability to anticipate delays, limitations to movement, and loss of momentum and thereby to extend operational reach, increase tempo, and prevent culmination of movement. Though this monograph's three hypotheses had mixed results, it revealed important lessons, including the importance of both meticulous planning and on-the-ground flexibility. In both cases studied, when planners anticipated changes, planned for delays, and made modifications, these actions resulted in forward movement and, ultimately, the Allied success in WWII.

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Abbreviations

ADP	Army Doctrine Publication
ASF	Army Service Forces
DOD	Department of Defense
ETO	European Theater of Operations
POL	Petroleum, Oil, and Lubricants
WWII	World War II

Introduction

Amateurs talk about tactics, but professionals study logistics.

—General Robert H. Barrow, USMC (27th Commandant of the US Marine Corps)

Military operations and their associated logistics have been intertwined and interdependent since the advent of organized armies. Although the concept is not new, the term 'logistics' is. Credited with its coining, Baron Antoine-Henri De Jomini defined logistics as "the art of moving armies."[1] He continued, "logistics comprises the means and arrangements which work out the plans of strategy and tactics," thus underscoring the importance of logistics at multiple levels of military planning and execution.[2] Even now, the current US Department of Defense (DOD) definition of logistics is very similar— "planning and executing the movement and support of forces."[3] This research investigates the logistics involved in port opening operations, specifically focusing on the logistical function of movement at the theater-level of operations. Current US joint doctrine states that the Theater Sustainment Command is the Army's logistics headquarters and "is responsible for executing port opening, theater opening, theater surface distribution, and sustainment functions in support of Army forces."[4] Finally, this research explores the concept of anticipation, which is a principle of sustainment, and related to logistical movement. "Anticipation is the ability to foresee operational requirements and initiate necessary actions that most appropriately satisfy a response without waiting for" further guidance or orders.[5] With this framework in mind, this monograph argues that theater-level military

[1] Baron Antoine-Henri De Jomini, *The Art of War*, trans. Capt. G.H. Mendell and Lieut. W.P. Craighill (Radford: Wilder Publications, 2008), 51.

[2] Jomini, *The Art of War*, 51–52.

[3] US Department of Defense, Joint Staff, Joint Publication (JP) 4-0, *Joint Logistics* (Washington, DC: Government Printing Office, 2019), GL-8.

[4] US Joint Staff, JP 4-0 (2019), III-10.

[5] US Department of the Army, Army Doctrine Publication (ADP) 4-0, *Sustainment* (Washington, DC: Government Printing Office, 2019), 1-3.

operations require logistical planners to anticipate forward movement, as assessed by three elements of operational art—operational reach, tempo, and culmination of movement.

The logistics of moving and supporting armies in Europe has challenged commanders since the Roman times; it also has played a decisive role in their victory or defeat. As Van Creveld wrote, "there is no question that sound logistics are absolutely essential for the successful conduct of war."[6] However, as multiple historical examples demonstrate, the ability to support and sustain the movement of military personnel and equipment is seldom studied in the detail required to improve the performance of future operations.[7] Therefore, the intent of this study is to assess the concept of anticipation of movement by way of three elements of operational art to improve future military operations. This research focuses on two historical case studies, examining the concept of anticipation in terms of planning and execution during two separate phases of port openings during the Allied advance in the European Theater of Operations (ETO) during World War II (WWII). The findings of these compared cases will assist to understand how anticipation of movement assists in extending operational reach, increasing tempo of operations, and preventing culmination of movement.

This research assesses the concept of anticipation of forward movement via the elements of operational reach, tempo, and culmination. The three chosen elements represent the most relevance for advancing logistic movement while also assessing the anticipation of forward movement. The US DOD definition of operational reach is "the distance and duration across which a force can successfully employ military capabilities."[8] Operational reach is, therefore, inherent in port opening activities that are designed to increase the forward movement of forces

[6] Martin Van Creveld, *Supplying War: Logistics from Wallenstein to Patton*, 2nd ed. (Cambridge: Cambridge University Press, 2004), 261.

[7] James A. Huston, *The Sinews of War: Army Logistics 1775-1953* (Washington, DC: Center of Military History, 1966), ix.

[8] US Department of Defense, Joint Staff, Joint Publication (JP) 3-0, *Joint Operations* (Washington, DC: Government Printing Office, 2018), GL-14.

over longer distances. Tempo is defined by US Army Doctrine Publication (ADP) 3-0 as "the relative speed and rhythm of military operations over time with respect to the enemy."[9] Dr. Leonhard writes that tempo can also be viewed through the lens of duration, frequency, and sequence to increase the effectiveness of logistical transportation systems.[10] Finally, culmination is defined as "that point in time and/or space at which the operation can no longer maintain momentum."[11] This concept is critical to all military operations because it is exactly what they are trying to avoid. These definitions help to frame how these elements fit into the larger theoretical framework.

The basis for the theoretical framework of this research is operational art. Logistics is a key part of all military operations as, "virtually all considerations entering into the major decisions of war are logistical."[12] This requires logistic planners to study the effects of extended supply lines and shortened duration of movement, while also considering the sequence and increased frequency of delivery, all while planning for the protection of supply lines from a loss or inability to maintain momentum. "Not only does logistics sustain the movement tempo of an army, it also sustains its force density."[13] Overall, anticipation within these elements of operational art is central to the hypotheses of this research.

This research examines the anticipation of movement from three separate and measurable perspectives—operational reach, tempo, and culmination. The first hypothesis is that, when theater-level logistic planners have extended operational reach, then they have anticipated delays

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[9] US Department of the Army, Army Doctrine Publication (ADP) 3-0, *Operations* (Washington, DC: Government Printing Office, 2019), 2-8.

[10] Robert R. Leonhard, *Fighting by Minutes: Time and The Art of War*, 2nd ed. (Scotts Valley: CrateSpace Publishing, 2017), 14–15.

[11] Joint Publication (JP) 5-0 US Department of Defense, Joint Staff, *Joint Planning* (Washington, DC: Government Printing Office, 2017), IV-36.

[12] Huston, *The Sinews of War*, 424.

[13] James J. Schneider, "Vulcan's Anvil: The American Civil War and the Foundations of Operational Art," School of Advanced Military Studies Theoretical Paper No. Four. (Fort Leavenworth: SAMS/USACGSC, 1992), 42.

and modified supply lines for more efficient movement. Second, when theater-level logistic planners have an appropriate tempo, then they have anticipated capacity bottlenecks and limitations to supply movement in both planning and execution. Third, when theater-level logistic planners have prevented culmination, then they have anticipated and corrected the logistical loss of the momentum of maneuver.

Using literary resources, relevant doctrine, and logistics research, this research centers exclusively on two cases of port openings in Northern Europe during the Allied advance in WWII. The first case focuses on the port openings at Normandy and several French ports while the second case concentrates on the port of Antwerp. Overall, this research is bounded from 6 June 1944 through 7 May 1945 and only focuses on Allied operations within the ETO.

This paper contains six sections. The first is a brief introduction defining the problem and the organization of the paper. A literature review detailing the relevant literary sources that represent the current body of knowledge explored in three subsections—theoretical, conceptual, and empirical—comprises the second section. The third section explains the structured, focused comparison case study methodology used in this research. The fourth section examines two different cases of port-clearing operations in Northern Europe during WWII. The fifth section presents findings and analysis. The final section offers the conclusions.

Literature Review

This review of relevant literature provides the theoretical, conceptual, and empirical structure for the subsequent methodology and case study analysis. First, a theoretical subsection introduces the theory of operational art as a lens to evaluate the concept of anticipation of movement. Second, a conceptual subsection defines the key terms in the three hypotheses in order to develop a clear criterion for evaluating the case studies. Finally, an empirical subsection assesses existing logistical research, focusing specifically on the extension of operational reach,

understanding of tempo, and preventing of culmination of military operations as outlined in the hypotheses above.

The theory of operational art is the lens through which this research assesses the concept of anticipation. The US joint definition of operational art is "the cognitive approach by commanders and staffs—supported by their skill, knowledge, experience, creativity, and judgment—to develop strategies, campaigns, and operations to organize and employ military forces by integrating ends, ways, and means."[14] These same approaches and skills are required in the supportive role of planning and executing logistics, on which this research is focused at the theater-level operations involving port openings and focused on anticipating movement. The US Army applies operational art to all aspects of operations with its own definition—"the pursuit of strategic objectives, in whole or in part, through the arrangement of tactical actions in time, space, and purpose".[15] While the theory of operational art has been refined over the years, the overall concept is not new.

Soviet Staff Officers and theorists in the 1920s and 1930s conceived the concept of operational art in response to then-recent technological advances. Aleksandr A. Svechin first used the term to describe the linkages and ultimately to "bridge the gap between strategy and tactics."[16] The Soviet military theorist Georgii Isserson further refined the theory with his concepts of deep battle, deep operations, and deep strategy.[17] Isserson's concepts highlighted the complexity of not only the future maneuver, but also the support of large forces, thereby driving fundamental changes to what the Soviets viewed as modern warfare. Mikhail Tukhachevskiy, the Soviet Army Staff Chief, began "to incorporate logistics into their operational-level exercises"

[14] US Joint Staff, JP 3-0 (2018), II-3.

[15] US Army, ADP 3-0, 2-1.

[16] Bruce W. Menning, "Operational Art's Origins," *Military Review* 77, no. 5 (1997): 37.

[17] Georgii Samoilovich Isserson, *The Evolution of Operational Art*, trans. Bruce W. Menning (Ft Leavenworth: Combat Studies Institute Press, 2013), 107.

and into planning because of an "understanding that logistics and rail and road nets played a key role in determining scale, scope, and depth of modern military operations."[18] This theory of operational art fundamentally changed how Soviet, and eventually US commanders, thought about warfare and, by extension, logistics, thereby driving changes to military strategy and the execution of military operations.

Dr. James Schneider points out, even before there was a term for it, commanders during the American Civil War were executing operational art with a new kind of "distributed logistics."[19] The significant and essential changes to how military forces were supplied are a direct result of the increased size of armies, troop formations, and required mobility of modern forces. "More significant from an operational standpoint was the fact that logistics could no longer sustain dense concentration of troops."[20] Therefore, from the beginning, the execution of operational art changed how commanders thought about how logistics impacted their options and strategy. As armies required more mobility, technologies like the development of the railroad not only increased the speed of troops and supplies, but also "ensured that modern warfare would have a uniquely distributed structure."[21] These revolutionary changes to warfare and logistical movement have altered commander's strategies. Consequently, as Dolman says, "every action of a master strategist should be intended to increase options, not eliminate them."[22]

An important principle of sustainment is anticipation, that is, being able to "foresee [the] operational requirements and initiate necessary actions" of movement; planners should also exhibit qualitative and even artistic properties.[23] These properties include "creativity, intuition,

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[18] Menning, "Operational Art's Origins," 38.

[19] James J. Schneider, "The Loose Marble-and the Origins of Operational Art," *Parameters* 19, no. 1 (1998): 91.

[20] Schneider, "The Loose Marble", 91.

[21] Schneider, "The Loose Marble", 95.

[22] Everett Carl Dolman, *Pure Strategy: Power and Principle in the Space and Information Age* (New York: Routledge, 2005), 9.

[23] US Army, ADP 4-0, 1-3.

insight, determination, and mental flexibility [that] are important ingredients in the cognitive process underlying logistic decision-making."[24] Such a perspective will allow planners to view logistical problems differently and identify flawed planning, limitations, and potential delays, thus resulting in greater ability for movement and, by extension, maneuverability to "achieve positional advantage over an enemy."[25] Anticipation of forward movement is assessed in each of the three hypotheses by focusing on the elements of operational reach, tempo, and culmination of movement.

Operational reach is "the distance and duration across which a force can successfully employ military capabilities."[26] This research is concerned with extending operational reach through port opening activities to provide a continuous supply over the greatest possible distance during WWII. An example of such reach occurred during the American Civil War, when new technology, including the railroad network, increased the speed, distance, and flexibility of troop movements thereby outpacing the reach of foot-mobile and horse-drawn conveyances of the past. At the theater-level during the US Civil War, "the railroad system played a decisive role in establishing a continuous system of logistics."[27]

However, extended reach is of little import if movement only happens at an infrequent schedule or in the wrong order; in both cases, the logistical function of movement has failed. Therein lies the importance of tempo and its four subcategories—duration, frequency, sequence, and opportunity.[28] Duration of movement may often be included with operational reach and should be minimized in most cases thus allowing for more repetitions; this is also termed

[24] Moshe Kress, *Operational Logistics: The Art and Science of Sustaining Military Operations*, 2nd ed. (New York: Springer, 2016), 9.

[25] Schneider, "Vulcan's Anvil", 30.

[26] US Joint Staff, JP 3-0 (2018), GL-14.

[27] Schneider, "Vulcan's Anvil", 44.

[28] Leonhard, *Fighting by Minutes*, 14–15.

frequency, or the "pace at which things happen."[29] Such a pace must be modulated for the appropriate military effect on operations, thus ensuring that movement occurs in the specified order or sequence. Overall, these four aspects of tempo have the capability to improve the movement of large armies through "freedom of action" and "function of movement."[30] The danger of overextended operational reach or the loss of tempo are two reasons for the culmination of military operations.

Clausewitz was one of the first to write about culmination. In *On War* he wrote, "Should he reach a point beyond which he dare not go, should he feel he must expand to right and left in order to protect his rear, so be it: very likely his attack has reached a culminating point."[31] The same considerations are true for anticipating movement; when forces are no longer able to be supplied continuously, their objectives, timelines, and movement are in jeopardy. The duration in time and distance can be quantitatively measured from the beginning of the military operations to the point when forward momentum is no longer possible. Understanding the reasoning for such stalling of operations will help future operations planners.

The study of logistics is often seen as second-rate compared to the studies of warfare, maneuver, or strategy.[32] This research claims that such a perception is false; the concepts are linked and fundamentally intertwined. "Logistics facilitates movement, fires, and sustaining of the impetus and vitality of combat forces along time and space."[33] Of the significant amount of literature on the subject of military logistics, this research focused on three broad categories of works: historical studies pertaining to the logistical challenges of the Western Theater of Europe

[29] Leonhard, *Fighting by Minutes*, 15.

[30] Schneider, "Vulcan's Anvil" 42.

[31] Carl von Clausewitz, *On War*, ed. and trans. Micheal Howard and Peter Paret (Princeton: Princeton University Press, 1976), 626.

[32] Creveld, *Supplying War*, 239.

[33] Kress, *Operational Logistics*, vi.

during WWII; US military doctrinal publications; and both military and civilian publications focusing logistical concepts, forms, and processes.

Although there are "hundreds of books on strategy and tactics [that] have been written for every one on logistics … even the relatively few authors who have bothered to investigate this admittedly unexciting aspect of war have usually done so on the basis of a few preconceived ideas rather than examination of the evidence."[34] As Van Creveld points out, logistical findings in historical case studies contain gaps and require close scrutiny when such studies do appear. According to Van Creveld, gaps range from aspects of Napoleon's logistics to Rommel's supply difficulties in North Africa, among others.[35] In response to those gaps, he sought to answer the following questions across hundreds of years of military history. "What were the logistic factors limiting an army's operations? What arrangements were made to move it and keep it supplied while moving? How did these arrangements affect the course of the campaign, both as planned and as conducted? In case of failure, could it have been done?"[36] These questions accord with the goal of this research and influence the research questions focusing on port opening operations of the specified campaign.

In his research LTC James H. Henderson, US Army (Ret.) focuses on the theory and practical execution of logistics from a military standpoint. In particular, he outlines the need to clearly identify logistical support requirements for operations or risk the supporting personnel failing to understand the logistical environment which may require "a different battle rhythm in supporting and gauging the operational tempo of the distribution network."[37] Additionally, LTC Henderson addresses military logistic support tasks and systems at different levels of warfare. He

[34] Creveld, *Supplying War*, 231.

[35] Creveld, *Supplying War*, 2.

[36] Creveld, *Supplying War*, 3.

[37] James H. Henderson, *Military Logistics Made Easy: Concept, Theory, and Execution* (Bloomington: AuthorHouse, 2008), 15.

makes the point that understanding the logistical environment and how operations fit into the larger level of warfare are important to effective sustainment execution.[38] Such a broader understanding and perspective allows a logistics planner to anticipate the next steps required for forward movement. Therefore, proper execution requires a firm understanding of the operating environment and, even more importantly, the ability to visualize and communicate how logistics fits into combat operations.

Finally, because the research questions involve both quantitative questions like distance and duration as well as qualitative questions, the researcher reviewed a variety of literature on the study of logistics. Dr. Kress discusses the duality of the scientific or quantitative aspects of logistics with their counter point of the artistic or qualitative facets in *Operational Logistics*. He comments that logistics are often based on "physical factors, quantitative relations among parameters, formal rules, and a lot of data," whereas "the creative and nonformal attributes needed to run logistics include common sense, experience, imagination, the ability to improvise, and intuition–factors that represent the artistic facet of logistics."[39] The distinction between art and science assists in understanding whether anticipation of future operational requirements was successful, along with pinpointing the reason for any unsuccessful operations. Lt Col George C. Thorpe, US Marine Corps proposed another way to think about classifying logistics in what he termed pure and applied logistics. "Pure logistics is merely a scientific inquiry into the theory of Logistics–its scope and function in the Science of War, with a broad outline of its organization."[40] This results in a theoretical view of logistics specifically focusing on the boundaries and organizational components of logistics.[41] On the other hand, applied logistics

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[38] James H. Henderson, *"The So What Factor" of Logistics: The Science and Art of Military Logistics* (Bloomington: AuthorHouse, 2011), 4.

[39] Kress, *Operational Logistics*, 8.

[40] George C. Thorpe, *Pure Logistics: The Science of War Preparation* (Washington, DC: National Defense University Press, 1986), 5.

[41] Kress, *Operational Logistics*, 9.

utilizes theory, organization, and structure derived from "the study of pure logistics" in order to build a logistic system for deploying forces and supporting military operations.[42] These terms and concepts for classifying logistics provide a framework for the theoretical and practical understandings of the logistical cases studies.

The reviewed literature provides a framework to understand the anticipation of movement as a function of logistics. A clearer understanding of the logistical processes, concepts, and structures allows for greater understanding of both the successes and failures of anticipation in the upcoming cases studies in both quantitative and qualitative terms. Whereas there have been various logistical studies of military campaigns throughout history (in particular during WWII), there appears to be a void in the literature in attempting to derive lessons learned through a deeper understanding and comparison of similar port opening operations. Such knowledge would go a long way in avoiding the danger of repeating the same mistakes. This was clearly on Van Creveld's mind as he concluded his extensive research of military logistics—"in the face of this kaleidoscopic array of obstacles that a serious study of logistics brings to light, one sometimes wonders how armies managed to move at all, how campaigns were waged, and victories occasionally won."[43]

Methodology

This methodology section contains four parts. First, there is an explanation of the chosen research methodology. Second is an introduction to the two case studies used for data collection. Third consists of an introduction to the research questions and an explanation of how they relate back to the hypotheses. Finally, the concluding section presents the expected research outcomes. This structured approach ensures a thorough evaluation of each hypothesis and ultimately enables

[42] Kress, *Operational Logistics*, 9.

[43] Creveld, *Supplying War*, 231.

this research to offer lessons as to how anticipation of movement is assessed by the elements of operational reach, tempo, and culmination of movement.

This monograph utilizes a structured, focused comparison research methodology to evaluate the two case studies via five predetermined research questions.[44] The questions were designed to evaluate the concept of anticipation of movement used by logistical planners as assessed by three chosen elements of operational art. The benefit of this methodology is that the same structured and focused approach can be applied to similar cases in the future, resulting in an overall increased base of knowledge while also increasing the validity of any common conclusions.[45]

The two case studies concentrate on the anticipation of movement following Allied port opening operations in the ETO during WWII. This campaign was selected based on its unmatched size of port throughput, its specific relevance to future military operations on the continent of Europe with large-scale forces, and because of the significant body of relevant literature available. The two separate cases of port opening operations allow for the comparison between the two as part of the focused, structured comparison methodology. The first case study focuses on the initial lodgments at Normandy starting on 6 June 1944 and the seizure of the deep water port of Cherbourg on 27 June 1944.[46] This case will highlight the first Allied operations on the European continent along with the challenges anticipating the forward movement of the divisions disembarking to continue combat operations. The second case begins with the start of port operations at Antwerp on 28 Nov 1944.[47] Antwerp provided a second deep water port closer to the Allied advance and faced very different challenges, threats, and limitations to port

[44] Alexander L. George and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences* (Cambridge: MIT Press, 2005), 67.

[45] George and Bennett, *Case Studies*, 67.

[46] Charles R. Shrader, *United States Army Logistics, 1775-1992 An Anthology*, ed. Charles R. Shrader, Vol. 2 (Honolulu: University Press of the Pacific, 2001), 525.

[47] Shrader, *United States Army Logistics*,522.

operations in the ever-increasing Allied logistical network. The second case focuses on how planners anticipated these new challenges in both planning and execution. Taken together, these two cases provide a means for comparing the concept of anticipation for movement, through the lens of operational art.

This methodology structures the data collection through five focused research questions to compare the two cases. The first two research questions are nested under hypothesis one, questions three and four under hypothesis two, and question five under hypothesis three. Each of the three hypotheses relates back to the concept of anticipating movement, with the first assessing operational reach, the second assessing tempo, and the third assessing culmination of movement.

The first and second research questions (and the first hypothesis) focus on extending operational reach. How did the difference between the planned and the actual commencement of port operations affect the maneuver's operational reach as supported by logistics? How were the logistical supply lines changed or modified to clear the ports of entry? These questions analyze not only the duration of time between the planned and actual start of port operations, which help to understand reasons and timing for port delays, but also the affect of timing and methods in extending supply lines for both the first phase of operations from Normandy and Cherbourg and the second phase once Antwerp was added.

The third and fourth research questions (and the second hypothesis) focus on appropriate tempo. What were the logistical capacity bottlenecks or limitations to the port throughput? How did port capacity planning and execution affect the tempo of movement? These questions enable better understanding as to how tempo was adjusted in light of anticipated bottlenecks and limitations to capacity thus increasing the frequency of throughput as high as possible.

The fifth, and final, research question focuses on the third hypothesis, that of preventing culmination of movement. What caused the port-clearing logistical movement system to lose or no longer maintain momentum for maneuver? Maintaining momentum is the intention of any military operation and, therefore, both case studies examine causes of a loss of momentum. This

question is answered for each case to identify similarities or difference in potential causes for culmination of movement.

This research used a structured, focused comparison research methodology based on a combination of primary and secondary sources to answer the research questions for both cases. Sources included aggregate history information from the Center of Military History, focused research from the likes of Van Creveld and Eccles, among others, and primary sources such as field reports and after-action reviews from specific operations. These resources enabled focused data collection for each case centering on the concept of anticipation of movement. The answers to these research questions allowed for the focused comparison of the two case studies needed to assess the concept of anticipation via the three elements of operational art as separated in the three stated hypotheses. The following section will introduce and present the case studies.

Case Studies

The first case study focuses on the initial French lodgments at Normandy and the operations following the seizure of the port of Cherbourg. The second case study focuses on how operations changed after the seizure of the port of Antwerp in Belgium. Both case studies are presented with the same structure. First, an overview of each case sets them in time and space. Second, the structured research questions are answered for each case, using the same operational approach. Finally, after both cases are presented, they are summarized before presenting the findings and analysis section.

The time period immediately after the First World War was the first time in US history that countries planned for another large-scale mobilization. In the 1920s and 1930s, the Planning Branch Office of the Assistant Secretary of War, the Army Industrial College, and the Army and Navy Munitions Board were founded as agencies to continue “basic industrial mobilization

planning" during the interwar years.[48] Such a planning capacity was critical in the leadup to the Second World War; as Shrader wrote, "World War II was a war of logistics."[49] In fact, the first major "strategic decision" of the conflict centered on the logistics required to fight in two theaters; ultimately the Allies chose to focus initially on the European Theater, in part because of a lack of the logistical resources needed to commit to both.[50] Moreover, a shorter distance and, therefore, shorter lines of communication in the Atlantic over the Pacific Theater "permitted the build-up of adequate forces for a decisive blow in the European Theater."[51] In April of 1942, American and British forces began planning for a cross-channel invasion called Operation Bolero.[52] While the focus of the war effort remained on a cross-channel invasion, there was constant competition for resources from both outside and inside the ETO. Operation Torch in North Africa in 1942 as well as the decision to occupy Sicily in early 1943 both, for example, drew resources and personnel from what was then termed Operation Bolero.[53] As these examples show, despite multiple operations that delayed it, the ultimate cross-channel invasion—Operation Overlord—remained the central logistical focus in the ETO.[54]

This brief history provides a sense of the years of planning, multiple decision points, and numerous setbacks that went into the path to Operation Overlord. This research focuses on two key timeframes beginning with the execution of Operation Overlord—from the invasion of Normandy (6 June 1944) to the opening of Antwerp (28 Nov 1944) and then from the opening of Antwerp to the end of the conflict (7 May 1945). Specifically, these case studies examine the

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[48] Shrader, *United States Army Logistics*, 459.

[49] Shrader, *United States Army Logistics*, 477.

[50] Shrader, *United States Army Logistics*, 470.

[51] Shrader, *United States Army Logistics*, 482.

[52] John Kennedy Ohl, *Supplying the Troops: General Somervell and American Logistics in WWII* (DeKalb: Northern Illinois University Press, 1994), 182.

[53] Ohl, *Supplying the Troops*, 189; Shrader, *United States Army Logistics*, 485–86.

[54] Shrader, *United States Army Logistics*, 487.

concept of anticipation in planning and execution during the two periods of port opening logistics in an effort to understand the basis for those outcomes in terms of operational reach, tempo, and culmination.

French Ports – Normandy and Cherbourg

The initial period—6 June 1944 to 28 Nov 1944—includes the first beachhead taken by force on the European continent during WWII and continues through the capture and use of Cherbourg as a deep water port for the continued sustainment of military operations. "During the period between 6 June and 30 September 1944, 1,050,000 long tons of supplies and equipment were shipped directly to France from the United States … 1,680,000 long tons were transshipped from the United Kingdom to France for American forces, and 501,00 long tons from the Mediterranean."[55] It was the responsibility of the Army Service Forces (ASF) to ensure that "adequate port and beach capacities" were provided for the initial assault and follow-on forces.[56]

The first research question is: how did the difference between the planned and the actual commencement of port operations affect the maneuver's operational reach as supported by logistics? The central lesson from examining initial port seizures was the danger of sticking to an overly detailed plan as the environment changed and initial assumptions were proven false. Unlike the some hastily organized German operations, "the Allied Expeditionary Force invading France in June 1944 represented a triumph of foresight and organization."[57] Needing to build up resources and production capability, while also iterating multiple plans, the Allies developed a systematic organization to plan and execute their theater-level logistics. The Allies benefited from controlling the starting date of the campaign, for which "every movement had been planned in detail for two years on end."[58] Such comprehensive planning resulted in a thorough

[55] Shrader, *United States Army Logistics*, 489.

[56] Shrader, *United States Army Logistics*, 488–89.

[57] Creveld, *Supplying War*, 204.

[58] Creveld, *Supplying War*, 204.

understanding of what supplies were needed, including where and when. However, plans were halted in the first hours when the forces encountered heavy surf and fierce enemy resistance.[59] Planners quickly realized that the plan was too rigid to allow for contingencies and the "inevitable friction of war."[60]

The capture of deep water ports—in particular, Cherbourg—was critical to sustaining operational reach. Despite the detailed logistical plan of the Allies, Cherbourg "began operating six weeks behind schedule and it was several more weeks before it reached its scheduled capacity of 6,000 tons per day."[61] Other ports in the area, including Granville, Saint-Malo, and Brest, began operating too late to be useful during the initial push; others captured more or less on time "were too small to make any significant contributions to Allied supply."[62] Therefore, since the Allied forces failed to plan for such delays, they needed to find an approach to get the supply movement back on schedule. When faced with these delays in clearing ports of entry and after better assessing the capabilities of the beaches, the Allies adjusted their logistical approach by implementing innovative techniques such as the beaching of ships.[63]

The second research question is: how were the logistical supply lines changed or modified to clear the ports of entry? Initially, clearing the beaches progressed slowly and a limited number of exit roads resulted in a congested area, a prime target for the Luftwaffe.[64] To give a sense of the congestion level—"on the eve of operation 'Cobra,' the breakout of Avranches, there were confined within the space of 1,570 square miles 19 American and 17 British divisions totaling a million and a half men, with supplies for the former alone averaging

[59] Creveld, *Supplying War*, 209.

[60] Creveld, *Supplying War*, 209–10.

[61] Creveld, *Supplying War*, 211.

[62] Creveld, *Supplying War*, 211.

[63] Creveld, *Supplying War*, 211.

[64] Creveld, *Supplying War*, 209.

22,000 tons a day."[65] The ultimate problem with the initially planned logistical supply lines and associated timelines centered on faulty underlying assumptions. "As originally conceived, the logistic plans for 'Overlord' had been based on the assumption that the Wehrmacht would fight a systematic defensive campaign, putting up resistance along one river line after the other."[66] Such a campaign would require a slow and methodical pace with more resources required over a longer period of time. Furthermore, the planning assumed "seventy-five per cent of the railway network in France" would be destroyed, that poor road conditions would restrict truck companies' range, and that troop consumption of resources would remain constant.[67] All of these assumptions proved wrong under the leadership of "General Patton [who] refused to be tied down by logisticians' tables."[68] As resources began pouring into Europe, the Allies extended logistical supply lines by operating outside of original plans and by realizing (and then disregarding) the self-imposed nature of the restrictions in the original plan, such as mileage limitation on trucking and expected resource consumption rates.[69] The detailed planning resulted in some unexpected surpluses from lower-than-expected consumption rates of supplies such as petroleum, oil, and lubricants (POL) as tactical progress was slowed by a number of factors.[70] Other resources such as ammunition were quickly in a short supply as operations slowed.[71] Factors assisting the extension of Allied supply lines included the possession of more motor transport capability than any other army and "operating in favorable summer weather and over a road network that was

[65] Creveld, *Supplying War*, 212.

[66] Creveld, *Supplying War*, 213.

[67] Creveld, *Supplying War*, 213–15.

[68] Creveld, *Supplying War*, 214.

[69] Creveld, *Supplying War*, 214–15.

[70] Creveld, *Supplying War*, 212.

[71] Creveld, *Supplying War*, 212.

among the best and most dense in the world."[72] Additionally, the operating environment included a friendly population ready to offer assistance, along with limited enemy air interdiction.[73]

The third research question is: what were the logistical capacity bottlenecks or limitations to the port throughput? The ports themselves were the primary bottlenecks. The amount of cargo that can be offloaded, processed, and then moved on to the end user or to storage warehouses within a certain period of time defines a port's capacity. "The bottleneck, it was soon apparent, was reception capacity for both troops and supplies in France, and it was to decisively influence both the developing tactical situation in Normandy and the course of the summer's debate on strategy."[74] Since the first ports would be on the seized beaches of Normandy, both the logistics and maneuver planners had a series of difficult considerations in developing their logistical plan—"[t]he size and number of beaches, their gradient (a vital consideration if ships of all types were to come as close ashore as possible, thereby dispensing with complicated transfer-arrangements which would inevitably have become bottlenecks) as well as prevailing conditions of tides, wind and waves."[75] Initially, planners sought to use two artificial harbors to increase the capacity of the beaches; unfortunately, one of the harbors, Mulberry A, was destroyed by a storm shortly after it arrived at Omaha beach.[76] Ultimately, the real workhorses during the Normandy campaign were small boats and "the DUKW, the versatile 2 ½ - ton amphibious truck … [that] promptly proved itself completely indispensable to over-the-beach operations."[77] These conveyances, together with cross-loading from larger vessels, were a start, but the carefully-scripted logistical plan began to fall behind with all the time lost transferring supplies; the Army

[72] Creveld, *Supplying War*, 215.

[73] Creveld, *Supplying War*, 215.

[74] Robert W. Coakley and Richard M. Leighton, *The War Department: Global Logistics and Strategy 1943-1945* (Washington, DC: Government Printing Office, 1968), 370.

[75] Creveld, *Supplying War*, 207.

[76] Huston, *The Sinews of War*, 525.

[77] Huston, *The Sinews of War*, 522.

needed larger offloads and faster turns to increase their tempo. That vision was finally realized when the Navy "permitted the beaching of landing ships during low tide" thus allowing for faster cargo offload without additional resources.

A second port-related bottleneck centered on transshipping supplies through UK ports which required more time and resources to receive, repackage as necessary, and warehouse than was needed to support ongoing operations. As a response, fifteen days after D-Day "the New York Port of Embarkation worked out a plan for 'commodity loaded' ships that primarily carried one class of supplies."[78] Such a plan offered several benefits—time was saved searching for items when they were unloaded (as all class of supply was the same on the ship) and only the class of supply that was needed could be called into port. Moreover, "commodity loaded" ships acted as floating reserves thus saving critical port space until that class of supply was needed; there were 244 such ships in October 1944.[79] When the port operations—first at Normandy and later at Cherbourg—became the largest bottlenecks for the tempo of operations, the ASF used technological and innovative ideas to transfer cargo quickly, organize and prioritize cargo, and keep the unneeded cargo from restricting port operations. The most effective and flexible of these ideas was the use of the amphibious trucks—DUKWs—to ferry critical supplies and increase the frequency of movement.

The fourth research question is: how did port capacity planning and execution affect the tempo of movement? To answer this question (which presented itself early in planning), planners started with the end result in mind. Specifically, planners determined "the maximum number of divisions and supporting troops that could be moved to the Continent and maintained in combat" and then considered the tonnage of supplies required to sustain and support those troops.[80] Only after that did planners examine the capacity for the port and the beach discharge needed to ensure

[78] Shrader, *United States Army Logistics*, 489.

[79] Shrader, *United States Army Logistics*, 489.

[80] Shrader, *United States Army Logistics*, 504.

that the required offload was feasible.[81] Such plans required that the capacity requirements for troops, supplies, and port discharge be in harmony as they were all interrelated and thus required meticulous planning to move in tandem.

The Allies based the detailed logistical planning for Operation Overlord and follow-on supplies on assumptions worked out in the years prior to the invasion. Logistical planners focused on the port discharge capacity of the intended ports with careful consideration for expected troop requirements.[82] Calculations were based on the projected long tons per day to support the expected number of troops on the European continent. For example, in the first thirty days after D-Day (D+30), thru the use of the beaches, artificial harbors, and the capture and development of Cherbourg along with smaller ports, the Allies expected to have a discharge capacity of approximately 27,000 long tons per day to support the expected twelve landed divisions.[83] With the capture and improvement of additional port facilities the total capacity in the US sector was projected to be 36,940 tons per day by D+60 to support 16 divisions, 47,700 at D+90 to support 21 divisions, and 39,650 at D+120 to support 27 divisions.[84] However, in the early months each of these estimates proved unachievable with regard to maintaining the tempo of movement. Although the weather affected some beach operations, the lack of capacity from the port of Cherbourg and other minor ports caused the primary planning deficiency. “Cherbourg was planned to have a capacity of 5,000 tons per day by the end of June, and the smaller Normandy ports at least 2,500 tons.”[85] However, Cherbourg was not even operational until 16 July 1944, and the smaller Normandy ports only discharged 4,558 tons in June of 1944.[86] All told, the Allies

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[81] Shrader, *United States Army Logistics*, 504.

[82] Roland G. Ruppenthal, *The European Theater of Operations: Logistical Support of the Armies*, Vol. 1 (Washington, DC: Center of Military History, 1953), 463–64.

[83] Ruppenthal, *Logistical Support*, Vol. 1, 463–64.

[84] Ruppenthal, *Logistical Support*, Vol. 1, 464.

[85] Ruppenthal, *Logistical Support*, Vol. 1, 464.

[86] Ruppenthal, *Logistical Support*, Vol. 1, 464

reported a 118,723-ton deficiency of supplies from 6 to 30 June 1944.[87] As operations continued into July, beach operations came closer to meeting the planned discharge, although the lack of discharge from the other ports from 1-25 July brought the total supply discharge deficiency to 278,148 tons, effectively doubling the overall deficiency of planned supplies by the second month of port operations.[88] Fortunately, this overall supply tempo was sufficient for many classes of supply and even allowed the buildup of some reserves from lower-than-expected consumption rates.[89] In order to maintain the required supply capacity as the Allies began to 'breakout' from Normandy, the focus turned to the ports in Brittany with an understanding that both the previously estimated timeline of how long the ports took to capture and their ultimate capacity had been overestimated.[90] Additionally, as all useful ports were in Western France and the focus of operations was moving to the East, planners began to account for the fact that supply lines were getting longer.

The fifth research question is: what caused the port-clearing logistical movement system to lose or no longer maintain momentum for maneuver? The answer is twofold—first, a limited supply of POL and then of supplies in general. In planning the initial incursion, the Allies estimated each division would consume 650 tons per day. This estimate proved overly conservative; once the divisions started moving, consumption hovered around 300-350 tons per day.[91] The supply challenge then became one of distance, with twenty-two American divisions operating in France, sixteen of which were near the Seine river by late August 1944, a distance of approximately 250 miles from the main port of Cherbourg.[92] The combination of rapid force

[87] Ruppenthal, *Logistical Support*, Vol. 1, 464.

[88] Ruppenthal, *Logistical Support*, Vol. 1, 466.

[89] Ruppenthal, *Logistical Support*, Vol. 1, 466.

[90] Ruppenthal, *Logistical Support*, Vol. 1, 473–74.

[91] Creveld, *Supplying War*, 214–15.

[92] Creveld, *Supplying War*, 215.

movement East and slower-than-expected discharge of supplies meant that the "planned depot structure and method of operation were upset from the start."[93] Units soon became desperate for supplies such as rations, POL, and ammunition.[94] "In an effort to relieve the critical supply situation in the forward areas, the long-distance, through-highway system known as 'Red Ball' was inaugurated late in August with a large number of truck companies organized to move supplies from Normandy depots to the forward maintenance areas."[95] By 28 August 1944, transportation resources "were spread so thin and lines of communications were so extended that daily deliveries could no longer be relied upon with certainty."[96] By the end of August the inability to meet growing demands resulted in a shortage of gasoline that began to affect operations of both the US First and Third Armies by slowing and eventually stalling operations.[97] The gasoline supply was eventually stabilized through the use of multiple means of transportation including truck, railway, airlift, and a specifically designated pipeline by mid-September 1944.[98] As forces extended the supply lines further from depots in Normandy, shortages became apparent in all classes of supply. These shortages were primarily caused by a lack of or inadequate transportation of resources that had to be shared amongst the different command structures.[99] The solution would be to shorten the lines of communication and supply by opening a port of entry closer to the forward troops.

Antwerp Port Opening

The opening of port operations at Antwerp (28 Nov 1944) thru the end of the conflict (7 May 1945) defines the time period of the second case. This period offers a comparison between

[93] Ruppenthal, *Logistical Support*, Vol. 1, 493.

[94] Ruppenthal, *Logistical Support*, Vol. 1, 496.

[95] Ruppenthal, *Logistical Support*, Vol. 1, 496.

[96] Ruppenthal, *Logistical Support*, Vol. 1, 504.

[97] Ruppenthal, *Logistical Support*, Vol. 1, 506, 508.

[98] Ruppenthal, *Logistical Support*, Vol. 1, 510–11.

[99] Ruppenthal, *Logistical Support*, Vol. 1, 516.

the initial French port operations and how the operational reach, tempo, and potential for culmination changed as the major port of Antwerp was added to the logistical planning for Allied operations. Despite being captured relatively undamaged by British forces on 4 September 1944, Antwerp took a further three months to defend, clear, and ready for operation.[100] This delay restricted "supplies and transport [which] held back the Allied armies all along the front and prevented the early deployment of the full power of American divisions."[101] Any further delay in the opening of Antwerp, given the winter German counter-offensive and already limited supplies, could have delayed the final victory of the war in Europe.[102] As early as 27 September 1944, Brig. General Lord, the Communications Zone Chief of Staff wrote, "The most important project of all was the development of Antwerp as the major joint U.S.-British port on the Continent."[103] An examination of the period immediately following the opening of Antwerp's port reveals its impact on the Allied logistical system in Europe during that remainder of WWII.

The first research question is: How did the difference between the planned and the actual commencement of port operations affect the maneuver's operational reach as supported by logistics? The logistical lesson in this case study centers on timing and planning, or rather a lack thereof. The Allies had initially focused their resources on the port of Le Havre in accordance with their original plan that it, with Rouen, it would be the first ports to be captured on the Seine.[104] Then the British unexpectedly captured Antwerp mostly intact on 4 September 1944, prior to the port of Le Havre (captured, badly damaged on 12 September), with few resources available; this and the fact that Le Havre lay 225 miles west of Antwerp, meant that a decision

[100] J. L. Moulton, *Battle for Antwerp: The Liberation of the City and the Opening of the Scheldt 1944* (New York: Hippocrene Books Inc., 1978), 7.

[101] Moulton, *Battle for Antwerp*, 7.

[102] Moulton, *Battle for Antwerp*, 7.

[103] Roland G. Ruppenthal, *The European Theater of Operations: Logistical Support of the Armies*, Vol. 2 (Washington, DC: Center of Military History, 1983), 52.

[104] Ruppenthal, *Logistical Support*, Vol. 2, 48.

about which port to focus on needed to be made.[105] With current forces up to 250 mile east of the planned-for Seine ports, and extended lines of communication only putting a larger strain on already over extended transportation resources, focusing on Antwerp would have made the most impact for US forces. Antwerp's true advantage was its position 65 miles from Liege (a forward supply depot); Cherbourg was more than 400 miles away.[106] However, the original logistical plans called for the capture of these Seine ports at around D+120 to reduce British reliance on the beaches and, therefore, resources initially were focused on the Seine ports, well behind Allied forward lines.[107] Two other factors delayed Antwerp's development. The first was a concern for the security of the port as a whole and the ability of the enemy to interdict supplies due to the geographical layout. "The Allied Naval Commander-in-Chief, Expeditionary Force, immediate gave warning that both Antwerp and Rotterdam were highly vulnerable to blocking and mining, and that if the enemy was successful in these operations no estimate could be made of the time it would take to open these ports."[108] Second, and more important to Antwerp's initial development, was that the port remained within the British 21st Army Group's area of operations, on the "inside track along the coast."[109] Since the 21st Army Group's advance did not take them from coastal ports their supply situation was much better than the two American Army Groups; the British did not see the urgency in developing Antwerp, despite US calls for haste.[110] In early October, a full month after the port's capture, Colonel Whipple, the Chief of the Supreme Headquarters, Allied Expeditionary Force Logistical Plans Branch wrote "The failure to open Antwerp … is jeopardizing the administrative soundness of our entire winter campaign."[111]

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[105] Ruppenthal, *Logistical Support*, Vol. 2, 48.

[106] Ruppenthal, *Logistical Support*, Vol. 2, 49.

[107] Ruppenthal, *Logistical Support*, Vol. 2, 48.

[108] Ruppenthal, *Logistical Support*, Vol. 2, 50.

[109] Creveld, *Supplying War*, 221.

[110] Creveld, *Supplying War*, 222.

[111] Ruppenthal, *Logistical Support*, Vol. 2, 107.

Ultimately, it took General Eisenhower to finally convince Field Marshal Montgomery to make Antwerp the priority.[112] By the third week in October the First Canadian Army was tasked with clearing the mouth of the Schelde estuary as well as approaches leading to the port, completing this task by the first week of November.[113] The mis-prioritization of resources, perceived threat to mining, and lack of focus by British forces kept Antwerp from opening until the end of November, almost three months after the port was captured.

The second research question is: how were the logistical supply lines changed or modified to clear the ports of entry? The port of Antwerp's position was critical to shortening supply lines to forward troop positions. As stated above, Antwerp was only 65 miles from the First Army's forward supply depots in Liege and 250 miles from the Third Army's forward supply depots by rail.[114] These distances were significantly shorter than the US communication lines to Normandy (400-500 miles) and Cherbourg and Le Havre (350-400 miles).[115] Additionally, once the approaches to the port were cleared, Antwerp's far superior port clearance facilities could be utilized. "Antwerp alone possessed more than 500 miles of rails, plus ample marshaling yards, and was well tied in with a Belgian transportation network consisting of 3,250 miles of railways 1,370 miles of navigable waterways, including the Albert Canal, which connected Antwerp with the Meuse River."[116] "The matter of rail lines was particularly important because the rail capacity from Cherbourg and the beaches was only about 10,000 tons per day as against a [projected] discharge rate of 20,000, with the result that motor transportation bore a heavy burden at great cost to equipment."[117] By shortening the lines of communication and using

[112] Creveld, *Supplying War*, 224.

[113] Ruppenthal, *Logistical Support*, Vol. 2, 107.

[114] Ruppenthal, *Logistical Support*, Vol. 2, 49.

[115] Shrader, *United States Army Logistics*, 510.

[116] Ruppenthal, *Logistical Support*, Vol. 2, 104–5.

[117] Ruppenthal, *Logistical Support*, Vol. 2, 49.

rail lines with more capacity the Allies were able to leverage the superior port clearance facilities at Antwerp. Despite this, there were still delays as the port came online. Clearance by rail was initially delayed due to a shortage of available rolling stock. More importantly, clearance by barge was supposed to account for up to a third of Antwerp's discharge capacity, primarily via the Albert Canal.[118] However, "[d]elays in the removal of obstruction, particularly the wrecked Yserburg Bridge at the entrance, postponed the opening of the canal until 23 December, by which date 198 loaded barges had accumulated."[119] Inadequate and limited transportation and depot facilities continued to limit the ability of logistical planners to fully leverage the port's significant discharge capacity, thus limiting an overnight change in the Allies' operational reach.[120]

Despite these challenges, as well as Germany's winter offensive and attacks from V-1 and V-2 rockets throughout the end of 1944, Antwerp continued to operate, improve, and extend their lines of logistical operation.[121] By the end of January 1945, Antwerp was consistently discharging approximately 18,000 tons per day, more than any other port in Europe; the total US port discharge averaged 40-50,000 tons per day within the ETO.[122] "For the first time the Communications Zone enjoyed a surplus in discharge capacity, which permitted some choice in the use of ports and a more economic use of shipping and inland transportation."[123] The use of the port of Antwerp and its associated transportation network marked a turning point in the constant struggle against the overall logistical discharge capacity in the early weeks of 1945.

The third research question is: what were the logistical capacity bottlenecks or limitations to the port throughput? The port of Antwerp initially had a distribution problem that directly

[118] Ruppenthal, *Logistical Support*, Vol. 2, 111–13.

[119] Ruppenthal, *Logistical Support*, Vol. 2, 113.

[120] Ruppenthal, *Logistical Support*, Vol. 2, 113.

[121] Ruppenthal, *Logistical Support*, Vol. 2, 113.

[122] Ruppenthal, *Logistical Support*, Vol. 2, 116.

[123] Ruppenthal, *Logistical Support*, Vol. 2, 116.

affected the tempo of port operations. The distribution was first affected by limited transportation resources and then by limited storage capacity for US supplies arriving at the port in late 1944. As stated above, initial transportation delays in clearing the port were caused by limited rolling stock for the railway, obstructions to the canal, and motor transportation shortages, all pointing to a significant backup at the port. "Antwerp with all its magnificent facilities, lacked sufficient warehousing to permit sizable backlogging of cargo in the port itself, for it had been practice in peacetime to clear incoming cargo via rail highway, and canal immediately after it was unloaded."[124] Moreover, the distribution problem was exacerbated because both US and British forces shared Antwerp. As the port was located in the British zone of operations, the 21st Army Group initially had discouraged US operations because of the limited storage and concerns over distribution.[125] "Only a small amount of storage space, all of it uncovered, was allocated for American use"; the British had expected that the US cargo would be able to quickly be discharged to forward depots in Liege and, therefore, not require storage.[126] In late September 1944, "Colonel Potter, the [Communications Zone] G-4 plans chief, estimated that an accumulation of more than 15,000 tons (less than a day's intake) would create a serious obstacle to further unloading and outshipment."[127] "Within two weeks of the port's opening about 85,000 tons of cargo had already accumulated in sheds and under tarpaulins [at the] back of the quays, threatening to hamper unloading operations."[128] The problem was so out of control that, by mid-December, 100,000 tons of supplies were being stored on the US side of Antwerp with another 50,000 tons in space on loan from the British area.[129] This storage bottleneck led to further

[124] Ruppenthal, *Logistical Support*, Vol. 2, 111.

[125] Ruppenthal, *Logistical Support*, Vol. 2, 111.

[126] Ruppenthal, *Logistical Support*, Vol. 2, 111.

[127] Ruppenthal, *Logistical Support*, Vol. 2, 111.

[128] Ruppenthal, *Logistical Support*, Vol. 2, 111.

[129] Ruppenthal, *Logistical Support*, Vol. 2, 111.

distribution delays because there was no longer room to receive incoming shipments and not the transportation resources to get the accumulated supplies out, thus slowing tempo. These distribution delays reduced Antwerp's intake capacity through the first half of January 1945 when the transportation system had finally improved enough to start discharging the stockpiles.[130]

The fourth research question is: how did port capacity planning and execution affect the tempo of movement? Antwerp's shared status between American and British forces and the initial lack of interest and allocated resources by the British account for the slow start of the port operations as the logistical situation matured at Antwerp. Antwerp ranked among the world's largest ports with a discharge capacity between 80,000 and 100,000 tons per day; in "1938 alone it had registered 12,000 vessels and handled almost 60,000,000 tons of freight."[131] However, because planners were concerned with storage and transportation for clearing, "logistic planners had planned a maximum combined import at Antwerp of only 40,000 tons per day."[132] This intentionally limited cargo capacity at Antwerp was divided between the US forces (22,500) and the British (17,500); there was also geographical division of the berthing facilities and various port equipment.[133] Once the port was up and running and logisticians had remedied the initial transportation problems of clearing the port by rail, barge, and truck, the tempo of the intake began to fall due to the aforementioned storage capacity problem, discussed above.

Port operators and planners quickly set about solving the issues of storage and port clearance. In December 1944, Antwerp discharged 427,592 long tons or 27.5% of all tonnage at Continental ports.[134] The discharge tonnage rose to 433,094 in January, 473, 463 in February,

[130] Ruppenthal, *Logistical Support*, Vol. 2, 113.

[131] Ruppenthal, *Logistical Support*, Vol. 2, 113, 104.

[132] Ruppenthal, *Logistical Support*, Vol. 2, 111.

[133] Ruppenthal, *Logistical Support*, Vol. 2, 109.

[134] Ruppenthal, *Logistical Support*, Vol. 2, 124.

558,066 in March, and 628,227 in April amounting to 31% of the total discharge.[135] By April, Antwerp had surpassed Cherbourg, the Normandy minor ports, Le Havre, Rouen, Gent, and Southern France, with over a half million tons discharged.[136] Such an increase in output over such a short period of time is a testament to the hard work rectifying the storage and port clearance problems that challenged initial port operations.

The fifth research question is: what caused the port-clearing logistical movement system to lose or no longer maintain momentum for maneuver? Ultimately, despite a slower-than-desired spin-up time, the port of Antwerp and the associated logistical transportation system did not significantly lose momentum; shorter transportation distances and a maturing transportation network ensured maintained momentum. As stated above, the storage problem initially resulted in a decrease in Antwerp's intake capacity while the threat of bombardment from the V-weapon resulted in a limited embargo on ammunition due to safety concerns.[137] "Entirely apart from their high-pressure work in connection with the supplies that came into that port, the Transportation and other [Services of Supply] troops at Antwerp faced the danger of flying bombs, which came in during January and February at an average of about forty per day."[138] Despite the danger, the work continued to improve the speed and volume of discharge from the port of Antwerp. "Between December 18, 1944, and January 6, 1945, the Motor Transport Service of the Transportation Corps, at the height of the crisis of the German counterthrust near Bastogne, transported 67,236 troops and 10,800 tons of supplies and average distance of 100 miles from the Mourmelon district to the vicinity of Bastogne."[139] These enormous efforts stopped the German counter offensive, but were only possible because of shorter distances to be travelled from ports

[135] Ruppenthal, *Logistical Support*, Vol. 2, 124.

[136] Ruppenthal, *Logistical Support*, Vol. 2, 124.

[137] Ruppenthal, *Logistical Support*, Vol. 2, 114.

[138] Shrader, *United States Army Logistics*, 539.

[139] Shrader, *United States Army Logistics*, 539.

and depots with limited transportation resources. “The difference between Cherbourg and Antwerp as supply ports is shown by the fact that almost four times as much effort was required to support one division from Cherbourg as from Antwerp.”[140] Such a drastic difference in terms of the distance of supply lines equated to Cherbourg being able to support a maximum of 13 divisions, including reserve supplies, whereas Antwerp could support 50.[141] As the transportation system (railway, canal, and motor vehicle) matured ahead of the Rhine crossing, unprecedented movements of supplies became possible because of the forward location of ports like Antwerp supporting forward depots such as Liege. “In the month of February 1945, the yards at Liege handled 35,000 tons daily,” three and a half times the rail capacity from Cherbourg just five months earlier.[142] Equally as critical to the Rhine offensive build-up, the Motor Transport Division of the Transportation Corps moved “2,796,746 tons of supplies and 1,011,774 soldiers over the military highways to forward areas from February 11 to March 11.”[143] These actions show no signs of a loss of momentum due to appropriate distances to travel based on the resources available and those to be moved. These actions took extraordinary effort, but were possible through careful planning, innovation, demanding work, and the greatest mobilization of industrial resources in history.

The first case study focused on the initial French lodgments at Normandy and the operations following the seizure of the port of Cherbourg, while the second focused on how operations changed after the seizure of the port of Antwerp in Belgium. The same five research questions guided both cases in a structured way, with both case studies covering the same theater-level logistics in order to analyze why changes took place with the addition of Antwerp to the overall port capacity. When viewed through the lens of planning and execution, these cases

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[140] Shrader, *United States Army Logistics*, 539.

[141] Shrader, *United States Army Logistics*, 539.

[142] Shrader, *United States Army Logistics*, 540; Ruppenthal, *Logistical Support*, Vol. 2, 49.

[143] Shrader, *United States Army Logistics*, 540.

focused on the elements of operational reach, tempo, and culmination. In the following findings and analysis section, the structured research questions enable focused comparison between the two cases in order to test each of the three hypotheses.

Findings and Analysis

The answers to the structured research questions for each case study provide the basis for the following analysis. First, the findings subsection reviews the empirical data from each case study, structured by and focused based on the five research questions. Second, the analysis subsection compares these findings and determines if they support, do not support, or have mixed results for the three hypotheses. Ultimately, this section will conduct a structured, focused comparison of the logistical planners' ability to anticipate challenges in order to extend operational reach, develop an appropriate tempo, and prevent culmination in the ETO from the invasion of Normandy to the opening of the port of Antwerp and then from that port opening to the end of the conflict.

The first research question is: How did the difference between the planned and the actual commencement of port operations affect the maneuver's operational reach as supported by logistics? The delays in achieving planned port capacity played a critical role in both cases. In the first case, Cherbourg took six weeks longer than expected to capture and several more to prepare for sustained port operations. These delays caused the meticulous Allied planning to breakdown, requiring innovative solutions such as beaching of ships to offload faster and longer-than-planned use of the beaches. The delays could have resulted in disaster if the troop sustainment requirements had been as high as expected. Conversely, Antwerp was captured far ahead of schedule, but again took just shy of three months to begin port operations, again delaying the advantage of such a large port so close to the forward areas. Even though Cherbourg was captured behind schedule and Antwerp ahead of schedule, the true logistical impact resulted from

the delays getting the ports operational. These delays resulted in supply shortages and restricted movement, thus impacting Allied logistical operational reach, and delaying operations.

The second research question is: how were the logistical supply lines changed or modified to clear the ports of entry? The methods of extending the supply lines and thereby operational reach varied between the two phases studied. In the first phase of operations, commanders leveraged lower-than-expected resource consumption rates in order to operate outside of the initial, stringent planning requirements and restrictions, thus extending their reach. During the second phase, the port of Antwerp itself was critical to extending operational reach—it was much closer geographically to forward supply depots than any other port. Furthermore, Antwerp's capacity and close access to multiple modes of transportation via its significant railway network, highway system, and canals resulted in a greater ability for the Allied forces to extend their reach. One commonality in both phases of logistical operation was the importance of motor transportation in moving supplies and resources, thus offering flexibility and rapid movement over the existing European highway system.

The third research question is: what were the logistical capacity bottlenecks or limitations to the port throughput? In both phases studied, the ports themselves represented the greatest logistical bottleneck to throughput for a significant period of time after each port began operating. During the first case, the beach conditions and initial lack of established ports limited throughput. These conditions prevented or slowed large seagoing ships from offloading massive quantities of supplies thus limiting the early overall capacity. Planners were eventually able to reach the capacity demands at the beaches through innovative techniques such as beaching ships. Furthermore, planners began loading ships with only one type of supply; this, coupled with the heavy use of DUKWs to ferry small portions of supplies, aided in efficiency during the first phase of operations. During the second case, a lack of storage severely limited Antwerp's port capacity. With initial limited discharge capacity, particularly via railway and canal, incoming shipments clogged the limited storage space available resulting in further restriction of Antwerp's intake

capacity. The capacity limitations during the initial operations of both cases show limited throughput of resources and, as a result, slowed the tempo of the Allied movement.

The fourth research question is: how did port capacity planning and execution affect the tempo of movement? The planned port capacity during the initial stages of both cases was much higher than proved realistic. This resulted in much lower than planned throughput of supplies until a tipping point was finally reached in early 1945. When considering the initial operational phase, the ports were the limitation because they simply could not keep up with the capacity that Allied logisticians had planned. This was a result of the slow progress in capturing Cherbourg and lower-than-expected capacity at minor French ports; the latter had sustained more damaged than expected. During the second phase of operations, known storage problems limited the planned capacity at Antwerp; moreover, planners knew that the port (and its storage) would be shared with the British forces. Even that planned timing proved optimistic due to the challenges associated with the surrounding transportation system used to discharge the cargo from the port. In both phases, the ports were eventually able to meet or exceed the planned capacity after weeks or even months of lengthy delays. Once the capacity was increased, a greater burden was put on the transportation system to increase the tempo of supply movement. The true difference with the addition of Antwerp as a port of entry was the shorter lines of supply and communication. This led to a tipping point where the Allies finally had a surplus of capacity and a mature transportation network to move those supplies quickly.

The fifth research question is: what caused the port-clearing logistical movement system to lose or no longer maintain momentum for maneuver? The two cases presented opposing findings. In the first phase of operations there were clear causes for the lack of operational momentum. Specifically, the still-limited port capacity, long supply lines, and limited transportation resulted in a lack of POL which slowed the advance of the American Army Groups for the first part of September 1944. The opening and extension of new pipelines along with the utilization of all available means of transportation finally resulted in the ability of both Army

Groups to regain their momentum. In the second phase, despite initial challenges with the local transportation system, particularly the railway and canal system, as well as issues with storage requirements at Antwerp, the overall logistical system failed to lose momentum once the port of Antwerp was added. The momentum persisted because other port operations throughout the ETO were able to continue operating and account for any short-term reduction of capacity as the port of Antwerp worked through its transportation and storage problems. Furthermore, the addition of Antwerp so close to forward depots was a net benefit to the overall logistical system regardless of any setbacks in overall capacity. Ultimately, while there was a clear loss of momentum in the first phase studied, even setbacks during the second phase did not result in a loss of logistical momentum.

This study's first hypothesis asserts that when theater-level logistic planners have extended operational reach, then they have anticipated delays and modified supply lines for more efficient movement. The empirical evidence for hypothesis one has a mixed result. In both cases, the delays in capturing, readying the ports for use, or both resulted in a lack of operational reach which delayed operations and slowed potential movement. Both cases showed a failure to anticipate delays in port operations which resulted in a greater strain on the transportation systems thereby slowing movement within the theater. However, equally as important to operational reach, the two cases presented different methods of modifying supply lines. In the first case, planners realized that estimated requirements and planning assumptions were conservative, resulting in greater forward movement than expected with the limited resources available. In the second case, the location of Antwerp so close to the forward depots allowed for shorter supply lines and less strain on the transportation system thus allowing for greater forward movement. Moreover, both cases made extensive use of motorized truck transportation providing both flexibility and reach over the existing and extensive European highway system. Overall, the two cases reveal that operational reach can be extended with a combination of planning, on-the-ground flexibility, and hard work.

The second hypothesis states that when theater-level logistic planners have an appropriate tempo, then they have anticipated capacity bottlenecks and limitations to supply movement in both planning and execution. The empirical evidence shows a mixed result for hypothesis two. In both cases planners anticipated that the ports themselves, at least initially, represented the most significant bottlenecks. This assumption proved true in both cases. Since the initial port capacity was seen as a limitation, a slower opening tempo of operations was planned in both cases. In the first case, the expected port capacity was to increase at regular intervals, however even discounting the capacity of ports that were captured late like Cherbourg, the Allies failed to meet the planned port capacity goals for the first three months, effectively falling further behind the planned tempo of operations. In the second case, the Allied capacity at the port of Antwerp was intentionally limited due to anticipated storage problems and shared resources between the US and British forces. However, the planned initial port capacity again proved to be much higher than was realistic due to transportation challenges involved in clearing the port, specifically by railway and barge. Therefore, despite planners anticipating that the ports themselves represented the most significant bottlenecks to the port operations, they failed to plan for realistic initial port capacities in both cases resulting in a slowed tempo of port operations. As the theater matured through the early months of 1945 and the above capacity issues resolved, the tempo of movement increased and the overall distances of the supply lines were also shortened thus increasing tempo even further.

The third hypothesis argues that when theater-level logistic planners have prevented culmination, then they have anticipated and corrected the logistical loss of the momentum of maneuver. The empirical evidence suggests that hypothesis three has a mixed result. Specifically, military operations approached culmination during the first case study because of overly extended supply lines and a lack of resources, particularly POL. However, in the second case study, despite setbacks in both the port capacity and limitations in the transportation system, there was no threat of culmination. The different outcomes between the two cases resulted from the later period

benefiting from shorter lines of supply, a more mature transportation structure, and the ability to utilize multiple ports of entry. Therefore, in this analysis, the resources and maturity of the logistical structure mattered more than executing well planned logistics in staving off culmination of military operations.

In summary, the empirical evidence and analysis found mixed results in all three of the hypotheses. The concept of theater-level logistic planners using anticipation with regard to an ability to foresee delays in planning, limitations to movement, and loss of momentum appears to have some basis in operational art. After assessing this concept of anticipation with three elements of operational art—operational reach, tempo, and culmination—the hypotheses were neither supported nor not supported given the structured, focused comparison research methodology. However, given the two cases studied, when planners did anticipate changes, planned for delays, and made modifications, these actions resulted in forward movement and ultimately the Allied success in WWII.

Conclusion

This monograph argues that theater-level military operations require logistical planners to anticipate forward movement, as assessed by three elements of operational art—operational reach, tempo, and culmination of movement. The theater-level was chosen because, at that level, the Army Theater Sustainment Command "is responsible for port opening, theater opening, theater surface distribution, and sustainment functions in support of Army Forces," according to current doctrine.[144] These are exactly the operations detailed in the two cases studies. At the theater-level, this paper focused on planning for logistics which is defined above as "planning and executing the movement and support of forces."[145] Focusing specifically on the movement function of logistics, this monograph evaluates the concept of anticipation using three elements of

[144] US Joint Staff, JP 4-0 (2019), III-10.

[145] US Joint Staff, JP 4-0 (2019), GL-8.

operational art—operational reach, tempo, and culmination. The goal of this examination of anticipation was to better understand the effects of logistical planners' ability to anticipate delays, limitations to movement, and loss of momentum and thereby to extend operational reach, increase tempo, and prevent culmination of movement. Two cases of port openings during the Allied advance in the ETO during WWII provided an ideal data set for comparison.

This monograph uses a structured, focused comparison research method as part of a systematic approach to test three hypotheses. After a review of the relevant literature and theory of operational art, five research questions were developed to structure the empirical data around the hypotheses, each separately focusing on the elements of operational reach, tempo, and culmination. By using the same five question for both cases, this methodology developed comparable information that was then used to test the three hypotheses. Overall, the empirical data revealed mixed results for each of the three hypotheses, neither supporting nor not supporting the concept of anticipation of movement as assessed by the three elements of operational art.

Thorough examination of the two port-clearing case studies reveals several lessons. First, anticipation in planning and flexibility in execution are key to extending operational reach. Both cases provided contrary examples when the opposite was true because planners failed to anticipate delays in port operations, resulting in a greater strain on the transportation systems and slowing movement within the theater. Additionally, the second case provided a good example of how utilizing a forward port in Antwerp shortened the supply lines thus allowing for greater operational reach and forward movement. When considering the tempo of port operations, planners in both cases anticipated the initial port operations would be a capacity bottleneck and, therefore, a limitation to movement. However, again in both cases, planners failed to plan for realistic initial port capacities resulting in a slowed tempo of port operations. Finally, whereas the first case resulted in a loss of momentum, the second did not. This difference in outcome between the cases is a result of the more resources available and the maturity of the logistical structure in

the latter case; those factors mattered more than executing well planned logistics in staving off culmination of military operations.

This research holds significance for the division transportation officer, G4 operational planning team members, and even maneuver planners because it is focused on anticipation of forward movement within theater-level operations. The lessons and findings of this research should inform future planning by staffs and decision-makers as they consider anticipating movement at the theater-level throughout Europe. These findings should be able to inform commanders' decisions when considering the challenges, successes, and failures of planning port operations in the European Theater and when trying to extend operational reach, increase tempo, and prevent culmination of movement.

This research's cases studies focused on two phases of port opening operations exclusively in northern Europe during WWII. However, the same basic research questions could be applied to other cases within the functions of logistical movement or support. Moreover, the same methodology could be applied to other geographic regions, theaters, or alliances. Furthermore, these logistical lessons are not limited to WWII; other large-scale sustainment operations such as Desert Shield/Desert Storm could provide more recent and telling lessons. Ultimately, this research just scratches the surface on potential lessons to be learned. It does, however, provide a basic structure for standardized data collection allowing for focused comparison against any future research.

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