# Bridging Capabilities of Division Engineer Battalions in Supporting Tactical Mobility of Infantry Divisions: An Analysis of Existing Capabilities vis-a-vis Future Requirements

## Chapter I
## Introduction

### Problem Statement

Tactical mobility is one of the basic prerequisites for effective use of an Infantry Division for offensive and defensive operation. It can help commanders to keep the momentum going, maintain freedom of movement and focus combat power where and when it is needed. The Division Engineer Battalions (DEB) in the Bangladesh Army are important combat support units in Infantry Divisions which provides mobility, counter-mobility and survivability support (Rassel, 2022). Of the various functions, tactical bridging stands out as an important function of DEB since the ability to bridge water obstacles in time directly affects manoeuvre and the successful completion of missions. In the predominantly riverine environment of Bangladesh, where major rivers, distributaries, canals and seasonal water bodies often impede the movement in the tactical environment, the ability to establish a timely and effective tactical crossing is an integral part of the Infantry Division operation (Infantry Divisions in Battle, 2025)

Existing bridging capability of DEB is largely reliant upon the use of Bailey Bridges (BB), Heavy Pontoon Bridges (HPB), Light Floating Bridges (LFB) and Infantry Support Rafts. These bridging assets have been used for many years in the operations of the Bangladesh Army and are still used as the main bridging asset to cross water obstacles during tactical operations. But a lot has changed in the world of military operations. Modern land operations demand agility, high pace of operations, higher survivability and the ability to support ever more mobile and heavy combat systems. Meanwhile, the use of UAS, precision guided munitions and long range precision fires has made the activities of extended bridge construction and manpower intensive deployment procedures more risky. Therefore, some deployment constraints such as deployment time, Military Load Classification and equipment serviceability and operational flexibility can negatively impact the capacity of DEB to deliver timely mobility support during current and future operations (Operations of War, 2025).

These operational realities suggest that the current capability of DEB to provide a bridging capability is worth questioning to ensure it is still suitable for the tactical mobility needs of Infantry Divisions in current and future operational environments. To ensure seamless manoeuvre of Infantry Divisions in the changing operational landscape of Bangladesh, it is very important to have a clear picture of the capabilities and limitations of the existing bridging capabilities of DEB. It is also important to identify capability enhancement measures of DEB for the future operational environments.

**Literature Review**

Kabir studied how the Corps of Engineers has evolved in the defense requirements of the nation of Bangladesh. The study examined the topography of Bangladesh, threat perception and defence concept and underscored the need to enhance the capability of combat engineers to assist military operations (Kabir, 1997)**.**

Rahman spoke about the future roles of the Corps of Engineers in the 21st century and emphasized the need to build up the engineer capabilities in the light of changes in warfare and national requirements (Rahman M. A., 2001).

Hossain discussed the function of the Corps of Engineers in the 21st century from a Bangladesh viewpoint. Organisational restructuring and equipment needs were discussed as part of the study to meet future operational challenges (Hossain, 2011).

Uddin looked into the management of the engineer resources in support of the mobility of the field formations. In the study the effective use of engineer resources to maintain mobility of operations has been highlighted but the assessment of the effectiveness of the existing bridging assets has not been assessed specifically (Uddin, 2014).

Rahman assessed the effectiveness of the current bridging assets of Division Engineer Battalions to improve combat engineering efficiency of Infantry Divisions. The study identified existing bridges and recommended upgrading bridges, but it did not discuss the sufficiency of bridges to future Infantry Division needs (Rahman M. M., 2021).

The issue of improvement of Division Engineer Battalion bridging capability in relation to the mechanised force of the Bangladesh Army was discussed by Rassel. The study evaluated the compatibility of the current systems of bridges with mechanized forces and recommended capability enhancements to meet the needs for future operations  (Rassel, 2022).

Siddiqui assessed the water obstacle crossing capability of the DEB and technical and tactical issues that impact mobility. The study presented solutions on how to improve the river-crossing ability, but focused mainly on water obstacle crossing instead of the tactical mobility needs of Infantry Divisions (Siddiqui, 2022).

**The Research Gap**

The literature review shows that the previous studies have studied the development of the Corps of Engineers and engineer resource management, the present bridging capabilities and the water obstacles crossing operation in the Bangladesh Army. More recent studies also have evaluated the adequacy of existing bridging assets to bear mechanized forces and have determined several technical and operational constraints of present bridging systems. However, little research has been conducted that has comprehensively assessed how well the current bridging capability of Division Engineer Battalions can meet the tactical mobility needs of Infantry Divisions in both current and the future operating environment. Studies are currently focused mainly on bridging equipment technical characteristics or individual aspects of engineer support with little attention paid to the doctrinal needs, operational circumstances and empirical data from the operational user. Therefore, an evaluation of current bridging capabilities of Division Engineer Battalions is needed to ascertain the capability to respond to the tactical mobility needs of Infantry Divisions and the need to increase capabilities for the future operational environment.

**Scope of the Research**

The effectiveness of the existing bridging capabilities of Division Engineer Battalions in support to tactical mobility of Infantry Divisions of Bangladesh Army is assessed in this research. The emphasis of the study is on the operational use of the existing tactical bridging assets Bailey Bridges, Heavy Pontoon Bridges (HPB), Light Floating Bridges (LFB) and Infantry Support Rafts in the context of divisional operations. It examines the capability of these assets to meet present and anticipated future operational requirements by considering doctrinal provisions, operational characteristics and users' perceptions. This study deals only with the mobility function of Combat Engineers and does not consider counter-mobility, survivability, civil infrastructure, or procurement issues, unless they directly impact the tactical mobility of the Infantry Divisions. The analysis relies on the Bangladesh Army doctrine, relevant literature and empirical data which are gathered from the questionnaires, key informant interviews and focus group discussions among officers with combat engineering and Infantry Division experience.

**Area Chosen for Research**

The study was conducted in the area of operation and technical operations within the Bangladesh Army keeping the bridging in view as a support for Infantry Division's tactical mobility by DEB. Both policy and field level organizations involved in the planning, management, and use of tactical bridging capabilities were part of the study.

Technical domain comprised of the Engineers Directorate in Army Headquarters and the Engineers Centre and School of Military Engineering (ECSME). These organizations were identified to receive data on existing bridging assets, doctrinal considerations, and tactical bridging technical characteristics and training.

The operational domain included Infantry Divisions with their organic DEB. The formations were selected to examine the operational use of existing bridging assets, reveal practical issues involved in tactical river-crossing operations and determine their suitability in meeting the tactical mobility needs of Infantry Divisions in current and future operational scenarios.

**Significance of the Research**

The results of this research are expected to further help improve tactical mobility support for Infantry Divisions with an evidence-based assessment of current bridging capabilities of Division Engineer Battalions. This study will help military planners, commanders and Engineers Directorate to determine operational and technical constraints of the current bridging capability, and to make decisions on the development of the future capability. Results of the research might also help in the review of applicable doctrine, training and operational planning for tactical river-crossing operations. In addition, this study will be a reference for future study on combat engineering and tactical mobility/bridging capability of Bangladesh Army.

**Limitation of the Research**

The study assessed the bridging capabilities of all DEB collectively, rather than any specific DEB of any specific Infantry Division. The findings therefore reflect a general, army wide picture. They may not capture particular bridging issues of an individual Infantry Division, whose terrain, river profile and operational role can differ considerably, as shown in Table 2.1.

Because of the academic schedule and limitation of resources it was not feasible to conduct a full-scale field validation, including a real division-level gap-crossing exercise, to measure actual assembly times.

The data analysis is based on the technical manuals available and professional judgment of serving officers. Localized, universally standardized metrics for quantitatively measuring “Speed of Maneuver” across multiple modernized heavy platforms in varying riverine terrain are lacking.

**Assumptions**

The assumptions of the research are stated subsequently:

The technical data and professional opinion gathered from officers will be assumed to represent a general organizational view on the modernization and tactical mobility needs.

Respondents will be assumed to be technically knowledgeable with exixting equipment (Bailey/Pontoons) and modern platforms in order to be able to make informed views on the current bridging gap.

The respondents, regardless of unit affiliation or operational background, will be assumed to be giving neutral and objective feedback on the current situation of equipment readiness.

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## Research Objectives

### *Broad Objective*

To evaluate the effectiveness of the bridging capabilities of DEB in supporting the tactical mobility of Infantry Divisions, considering both existing operational baselines and future requirements for modernized maneuver.

### *Specific Objectives*

To assess the existing bridging equipment to determine both the present and future capacity for supporting the tactical mobility of an iInfantry Division.

To analyze the challenges of existing bridging assets of the DEB in meeting the present and future tactical mobility requirements of an Infantry Division.

To determine a modernization road-map for enhancing the bridging capabilities of DEB through equipment modification and the induction of automated systems to ensure the current and future tactical mobility of an Infantry Division.

## Research Questions

### *Primary Question*

How effective is the existing bridging capability of DEB in meeting the present and future tactical mobility requirements of an Infantry Division?

### *Secondary Questions*

What is the current level of mobility support provided by the existing bridging assets of a DEB to an Infantry Division in relation to present and future requirements?

What are the challenges of existing bridging assets of the DEB in meeting the present and future tactical mobility requirements of an Infantry Division?

How can the bridging capabilities of DEB be enhanced through equipment modification and the induction of automated systems to ensure the current and future tactical mobility of an Infantry Division?

## Research Hypothesis

Modernization of bridging assets of DEB may significantly enhances the tactical mobility of an Infantry Division in meeting both present and future requirements.

## Research Variables

***Independent Variable:*** Modernization of Bridging Equipment of DEB.

***Dependent Variables:*** Tactical Mobility of Infantry Divisions.

There is a direct and positive correlation between equipment modernization and tactical mobility. Increased mechanization leads to a measurable reduction in assembly time and an increase in load safety margins.

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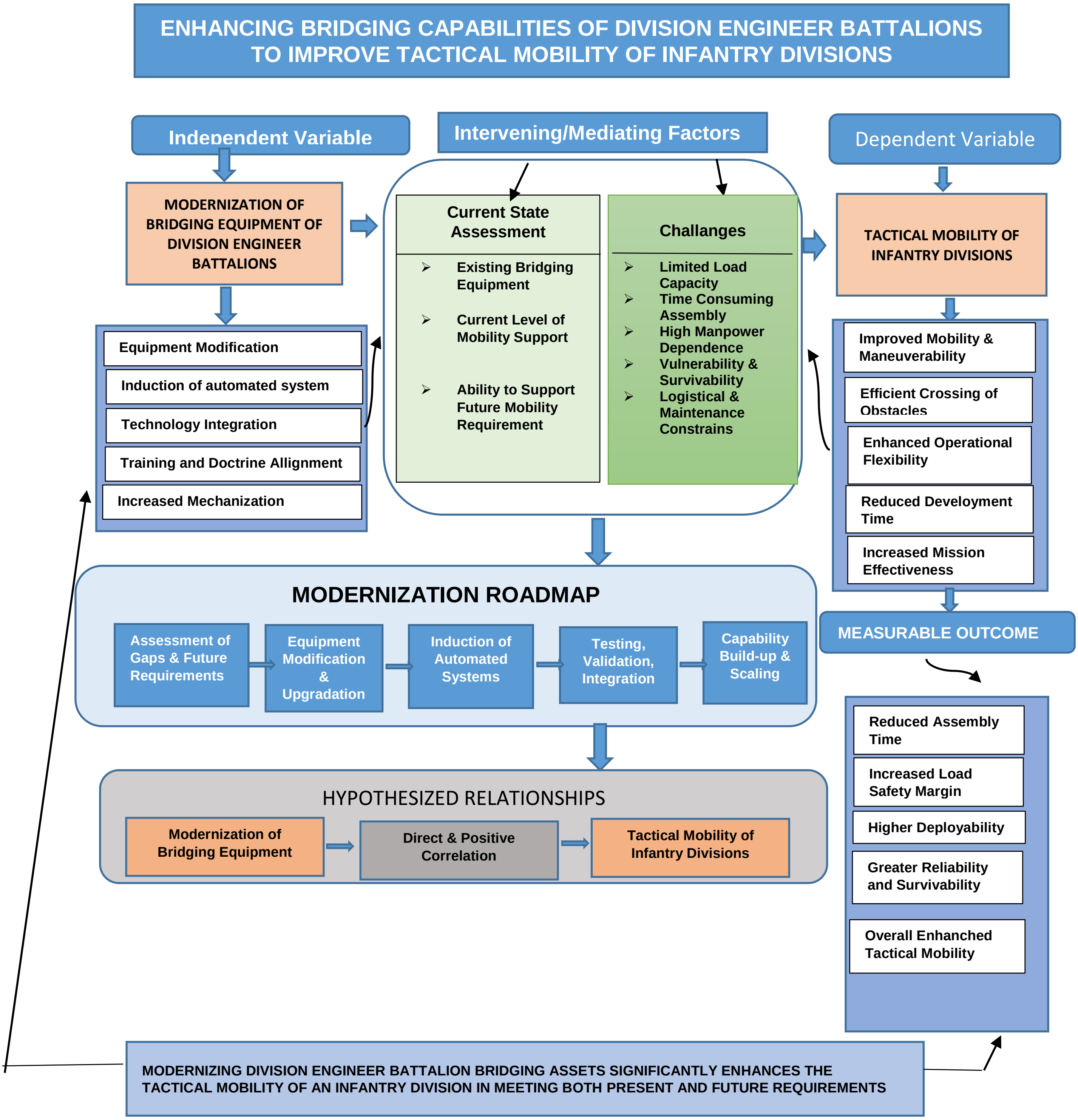
**Conceptual Framework**

**Figure 1.1**

*Conceptual Framework*

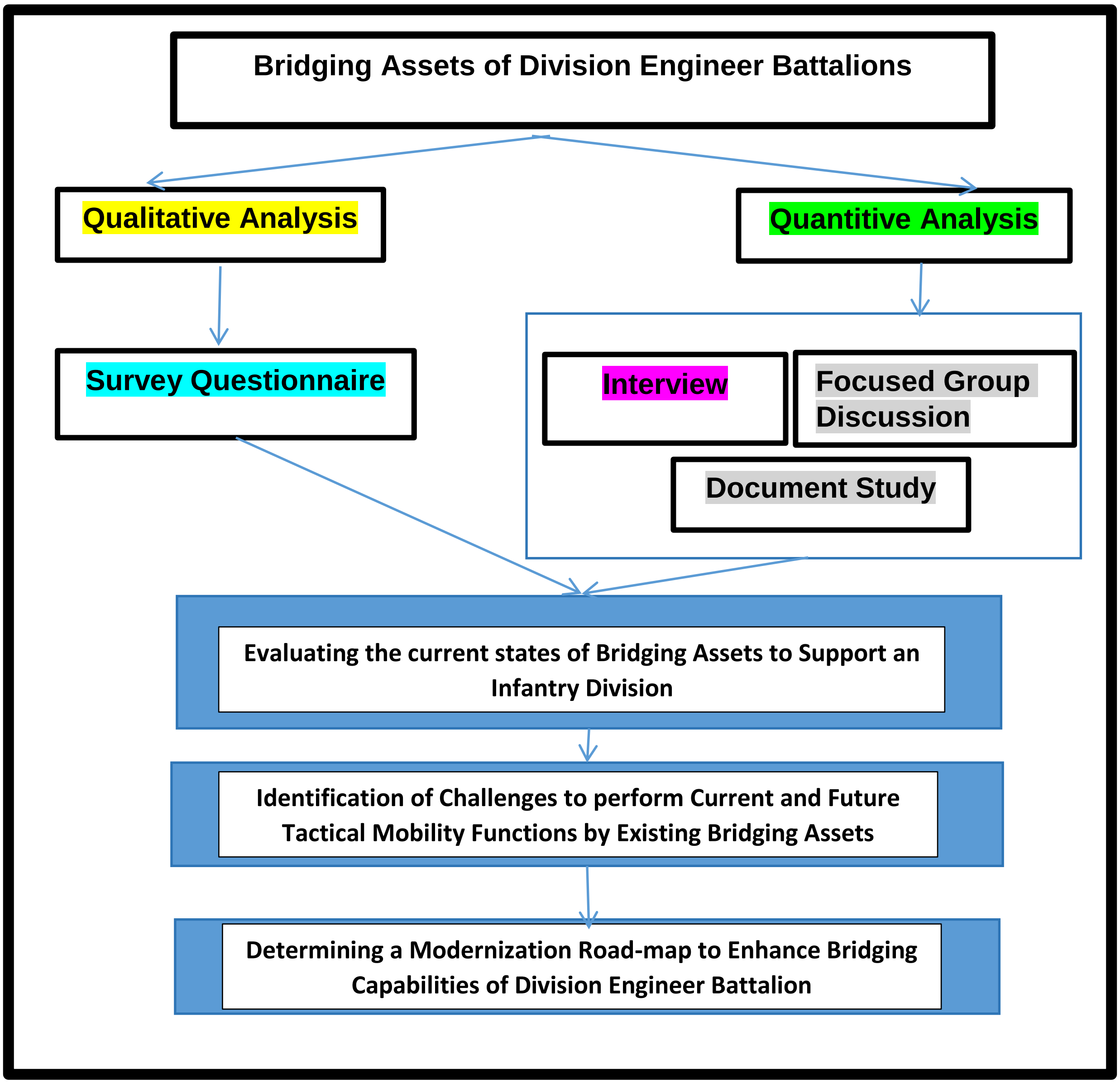



*Note: Researcher's Own Construct*

**Operationalization**

**Figure 1.2**

*Operationalization Diagram*




*Note: Researcher's Own Construct*

**Research Methodology**

The problem was investigated by using a mixed method design. Survey and secondary data study methods will be used.

**Table 1.1**

*Research Methodology vis-à-vis Research Objectives and Research Questions*

| Serial | Research Objectives | Corresponding Research Questions | Methods |
|---|---|---|---|
| **1.** | To assess the existing bridging equipment of DEB to determine both the present and future capacity for supporting the tactical mobility of an Infantry Division. | What is the current level of mobility support provided by the existing bridging assets of a DEB to an Infantry Division in relation to present and future requirements? | Survey among officers, Technical Manual Study, FGDs and Interview, |
| **2.** | To analyze the challenges of existing bridging assets of the DEB in meeting the present and future tactical mobility requirements of an Infantry Division. | What are the challenges of existing bridging assets of the DEB in meeting the present and future tactical mobility requirements of an Infantry Division? | Survey among officers, Technical Manual Study, FGDs and Interview |
| **3.** | To determine a modernization road-map for enhancing the bridging capabilities of DEB through equipment modification and the induction of automated systems to ensure the current and future tactical mobility of an Infantry Division. | How can the bridging capabilities of DEB be enhanced through equipment modification and the induction of automated systems to ensure the current and future tactical mobility of an Infantry Division. | Survey among officers, Expert Interviews, Comparative Case Studies |

*Note: Researcher's Own Construct*

**Data Collection Method**

There were two types of data collection – primary and secondary. The primary data were obtained through the structured surveys, interviews and Focused Group Discussions (FGD) techniques from the subject matter experts. Secondary data sources were technical manuals, professional journals and military periodicals, as well as official policy documents.

**Data Analysis Plan**

The data were analysed using both quantitative and qualitative techniques. The collected data from structured questionnaires were coded, entered and analysed using SPSS. Descriptive statistical techniques like frequency, percentage, mean and standard deviations were used for analysing the responses and presented in tables and figures. Thematic analysis of qualitative information gathered from Key Informant Interviews (KII) and Focus Group Discussions (FGD) was conducted to highlight salient points, trends and expert views. The qualitative results were then triangulated with quantitative results and literature to support in the comprehensive interpretation and discussion of the research results.

**Ethical Considerations**

The respondents were allowed to voluntarily answer the given questions and assured of the confidential handling of their information. Adequate control of all equipment holdings and capabilities was maintained in accordance with the security classification of the research.

**Sample Size**

In this research, the size of the samples was 120 people. Random sampling were used for quantitative analysis and purposive sampling were used for qualitative analysis to gain insights from senior engineer officers and technical experts.

**Study Sites**

The study was carried out in selected Bangladesh Army establishments such as Army Headquarters in Engineers Directorate, Engineers Centre and School of Military Engineering (ECSME), 14 Independent Engineer Brigade Headquarters. All Infantry Divisions and their organic DEB were considered in this study. These organizations were chosen because of their direct involvement in the planning, management, training and operational employment of tactical bridging capabilities.

**Study Duration**

February – October 2026.

**Chapter Outline**

***Chapter I*: Introduction**

Includes the problem statement, research questions, and methodology.

***Chapter II*: The Current Level of Mobility Support Provided by Existing Bridging Assets**

Examines the capacity of existing bridging equipment in relation to the present and future mobility requirements of an Infantry Division.

***Chapter III*: Challenges of Existing Bridging Assets in Meeting Present and Future Requirements**

Identifies the specific technical and operational challenges faced by the DEB in supporting modern tactical mobility to an Infantry Division.

***Chapter IV*: Enhancing Bridging Capabilities of Division Engineer Battalions for Desired Tactical Mobility of Infantry Division**

Determines the modernization road-map required for ensuring current and future tactical mobility for the Infantry Division.

***Chapter V*: Conclusion and Recommendations**

Provides a summary of findings and strategic recommendations based on the analysis.

# [redacted]Chapter II

# Current Level of Mobility Support Provided by Existing Bridging Assets

## General

The ability to move freely tactically is essential to military activities, especially in Bangladesh, where divisional AORs have many rivers, canals, water obstacles which slow down the tempo of military operations and hinder manoeuvre. Thus the mobility support of Division Engineer Battalion in terms of its bridging resources is very much critical to the movement of combat elements, combat support elements and combat service support elements across such obstacles (Kabir, 1997; Uddin, 2014). The current status of mobility support with the existing bridging assets is analysed in this chapter based on the survey findings, SPSS analysis, KII and FGD.

## Geography of Operational AOR and Bridging Support Requirement

The Brahmaputra–Jamuna, Ganges–Padma and Meghna river systems and their tributaries, canals, and wetlands create operational areas in Bangladesh, which impact military planning and operations. These have also been known to change seasonally, with the width of the rivers and crossing needs being significantly more during the monsoon season when water levels rise and low lying approaches are flooded, adding strain to the bridging resources available to each formation. As a result, the operational Areas of Responsibility (AORs) of Infantry Divisions vary significantly with regard to terrain, river density and water obstacles.

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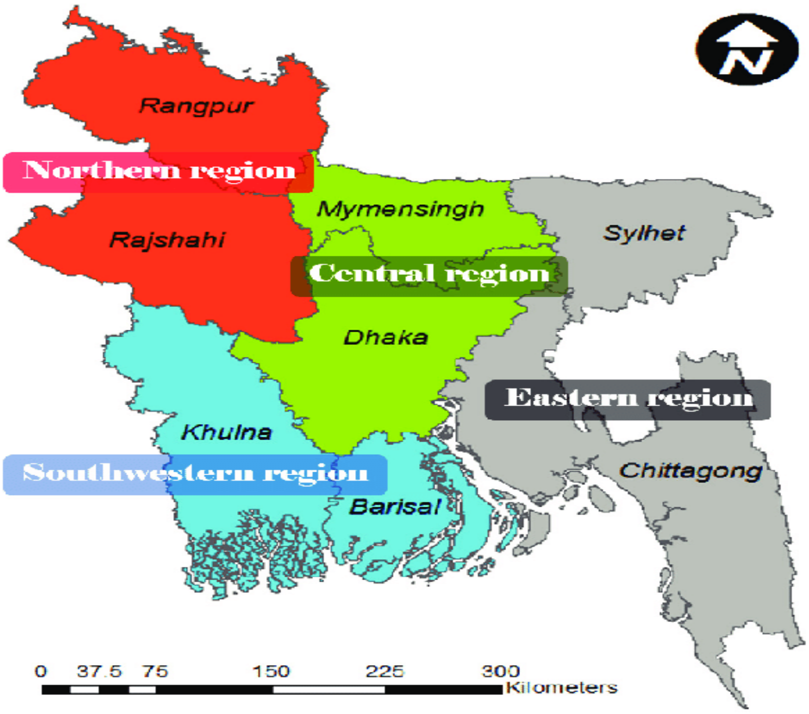
**Figure 2.1**

*Four Geographical Parts of BD* (Islam, 1990)




The major river systems within the operational areas of Infantry Divisions are summarised in Table 2.1.

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**Table 2.1**

*Major River Systems and Bridging Implications within the Operational Areas of Responsibility Infantry Divisions* (Islam, 2000)

| Formation / Operational Area | Major Rivers | General Characteristics ( In Dry Season) | Implication for Tactical Mobility | Remarks |
|---|---|---|---|---|
| 66 Infantry Division (Rangpur–Dinajpur) | Karatoya, Buritista (Atrai), Ghaghat, Tista | Comparatively dry and open terrain; most rivers are less than 100 m wide during the dry season except the Tista | Limited major bridging requirement with selected river-crossing support | |
| 11 Infantry Division (Bogra–Naogaon) | Karatoya, Mahananda, Atrai, Choto Jamuna | Mixed terrain with rivers generally below 200 m; several rivers are fordable during the dry season | Moderate bridging requirement for maintaining operational mobility | |
| 9 & 19 Infantry Divisions (Mymensingh–Dhaka Axis) | Brahmaputra, Lauhajang, Turag, Gorai, Banar | Numerous rivers and canals; widths generally range from 100–350 m during the dry season | High dependence on bridging assets to sustain operational manoeuvre | |
| 9 Infantry Division & 46 Independent Infantry Brigade (Central Region) | Buriganga, Lakhya, Kaliganga, Dhaleswari | Several strategically important rivers ranging from approximately 150–300 m in width | Continuous bridging support is essential for operational movement | |
| 33 Infantry | Titas, | Numerous rivers | High | |

| | | | | |
|---|---|---|---|---|
| Division (Comilla-Brahmanbaria) | Gumoti, Dakatia, Muhuri | and canals; widths generally range from 100–200 m | dependence on bridging assets to sustain operational manoeuvre | |
| 55 and 7 Infantry Division ( Khulna-Jashore) | Chitra, Kumar, Madhumati, Nabaganga, Garai | Rivers generally 150-200 m wide | Moderate bridging requirement for maintaining operational mobility | |

As seen in Table 2.1, the river distribution, width and terrain are very different for the various operational environments; some have a relatively simple environment with few rivers; others have many major rivers or canals, resulting in significant river-crossing requirements. However, the resources that are typically authorised to bridge are similar across Division Engineer Battalions. This variation also precludes the use of a single engineer support plan for all formations and requires a plan unique to each Infantry Division's river-crossing profile. Existing bridging capability, however, must be judged based on the particular operational environment and mobility needs of the Infantry Division served, rather than just technical capability.

**Operational Employment and Tactical Mobility Requirements of Infantry Divisions**

An Infantry Division can be used in Defensive, Counter Offensive and Limited Offensive operations in its Area of Responsibility. The layered defence concept relies on the mechanised components to carry out covering-force battles, counter-penetration, counter-attack and mobile defence, depending on speed, timely concentration and uninterrupted manoeuvre. Rivers and canals are significant barriers to this manoeuvre, and effective engineer support is critical in maintaining the momentum in operations (Rassel, 2022)**.**

The division has to shift armour, mechanised infantry, artillery, air defence and logistic echelons through multiple gaps (wet and dry) in counter-attack and limited offensive operations, demanding terrain analysis and adequate bridging resources throughout the routes of advance. However, in many sectors, one Bridge Company with a 91-metre capability might not be enough, and the existing inventory does not include self-propelled systems like bridge-laying tanks and armoured vehicle-launched bridges (Jubayer, 2022; Wahidul, 2022).

The tactical mobility needs of an Infantry Division are, therefore, not just about the mobility of the infantry components but also involve the seamless mobility of heavy combat platforms, supporting arms and sustainment elements. Bridging support shall offer appropriate load classification, adequate capacity, and timely deployment and flexibility for deliberate and hasty crossing; failure to do so slows down manoeuvring forces, thereby diminishing the effect of counter attack and exploitation.

**Existing Bridging Equipment Capability of Division Engineer Battalion**

The Division Engineer Battalion consists of a Battalion Headquarters, three Field Companies, Bridge Company, Plant Company, EME Workshop Section and administrative support elements. Field Companies offer close engineer support and heavy engineer jobs are under the control of the Plant Company, whilst the Bridge Company is a company specifically set up to build bridges and conduct river crossing operations in support of the Infantry Division (TO&E, 1991)**.**

The Bridge Company (TO&E, 1991) is comprised of one 91-metre Class-50 Heavy Pontoon Bridge, a 280-foot Class-9 Light Floating Bridge, six Infantry Support Rafts (Haque, 2015)**.** The Heavy Pontoon Bridge can be assembled as eight Class-30, six Class-40 or four Class-50 rafts, depending on the configuration (Al-Razi, 2021) but it can be equipped with only two ramp sets, which restricts the number of ferry sites to two (Hasan, 2021). This represents a constraint on the number of heavy vehicles that can cross a water obstacle through this ferry site and therefore, is a constraint on tactical mobility during large-scale mechanised movement, not necessarily a constraint on the raft configuration of the Bridge Company. Existing assets and their capabilities as presented in Table 2.2

**Table 2.2**

*Existing Bridging Assets of the Division Engineer Battalion and Their Operational Capabilities*

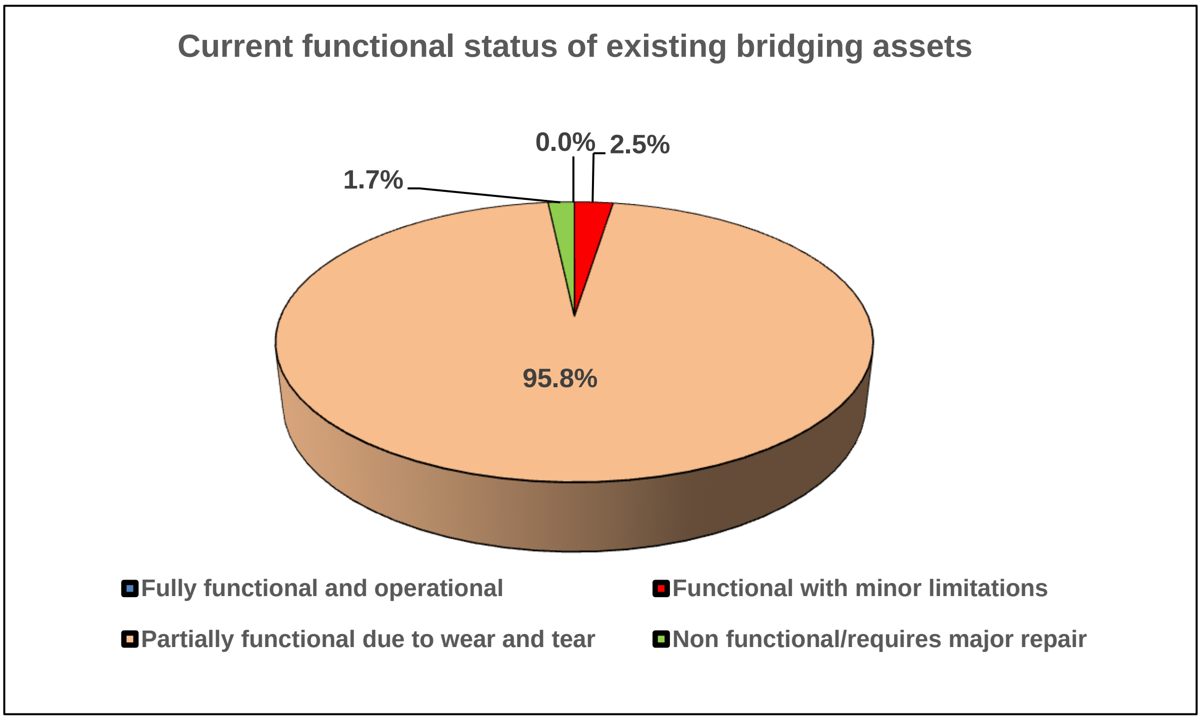
| **Bridging Asset** | **Classification / Capacity** | **Maximum Bridge Length / Span** | **Raft Capability** | **Erection Time*** | **Suitable Obstacle** | **Suitable Military Load** | **Primary Employment** |
|---|---|---|---|---|---|---|---|
| Bailey Bridge | Class 40 (depending on configuration) | 80 ft (authorised set) | N/A | Refer Bailey Bridge Manual | Dry gaps, damaged bridges, canals, culverts | Tanks (within authorised MLC), APCs, artillery, logistics | Restoration of routes and short-gap crossing |
| Heavy Pontoon Bridge (HPB-74) | Class 50 | 91 m | 8 × Class-30 / 6 × Class-40 / 4 × Class-50 rafts | Refer HPB-74 Manual | Medium and major rivers | MBTs, APCs, artillery, heavy logistics | Tactical river-crossing and ferry operations |
| Light Floating Bridge | Class 9 | 280 ft | N/A | Refer HPB-74 Manual | Narrow rivers and water obstacles | Light vehicles and personnel | Light tactical crossing |
| Infantry Support Raft | Personnel raft | N/A | Six authorised rafts | Refer HPB-74 Manual | Rivers and canals | Infantry and light equipment | Assault and initial river-crossing operations |

*Source: Table of Organization and Equipment* (TO&E, 1991)*; Bailey Bridge Manual; Heavy Pontoon Bridge (HPB-74) Manual;* (Haque, 2015)*;* Al-Razi (2021).

**Functional Status of Existing Bridging Assets**

**Figure 2.4**

*Current Functional Status of Existing Bridging Assets Considering Aging and Wear*




Existing bridging assets have a direct impact on Battalion functional capabilities to provide tactical mobility continuity. The respondents evaluated the current condition of these assets, taking into account the ageing and wear and tear, as follows: 95.8% respondents said partially functional due to ageing and wear and tear; 2.5% said functional with minor limitations; 1.7% said non-functional or requiring major repair; and none response fully functional. These findings show that, whilst the current stock is still sufficient to undertake the operational tasks, the effectiveness of this stock has been gradually impacted by the prolonged use of the equipment and ageing.

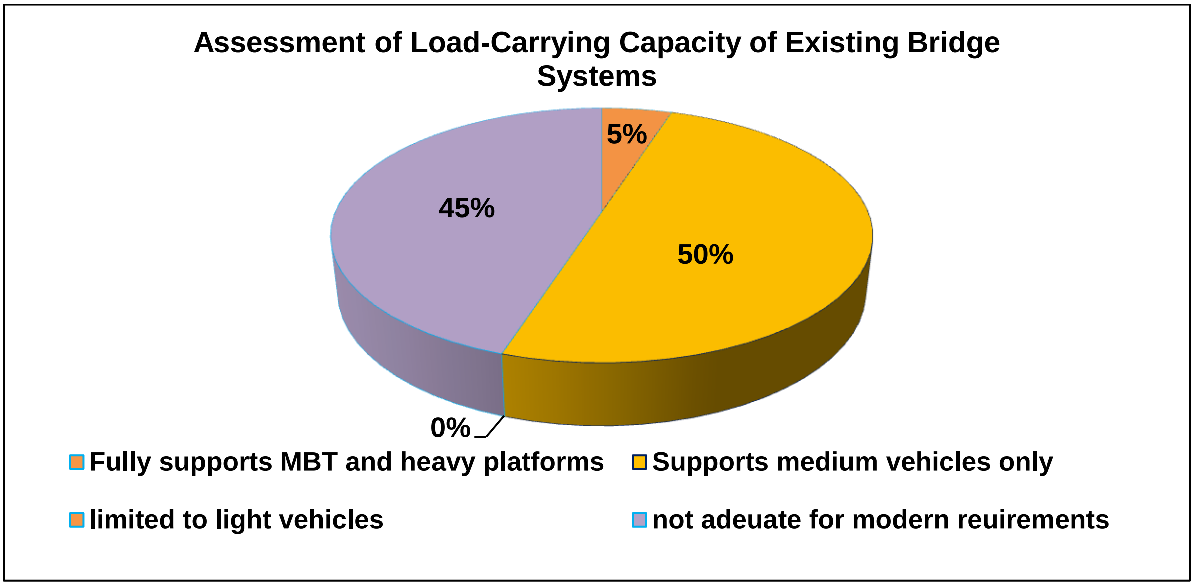
This is corroborated by the qualitative results. Engineer senior officers during the KII, agreed that the Bailey Bridge, HPB-74 and other associated assets are reliable within the limits of their authorisation, but that the need for increased maintenance, ageing and reduced efficiency in deployment is increasingly apparent;

FGD participants also highlighted the need for better maintenance and technical attention for the assets. The assets are generally operationally serviceable and fulfill tactical mobility requirements as outlined in the Manual for Bailey Bridges, HPB-74 Manual and TO&E which focuses on the importance of preventative maintenance. Implications for future modernization are discussed in Chapter III.

**Existing Capability of Bridging Assets to Support Tactical Mobility**

**Figure 2.6**

*Assessment of Load-Carrying Capacity of Existing Bridge Systems*




The capability of a bridging system to support tactical mobility largely depends on its ability to safely carry combat, combat support and combat service support vehicles. The existing assets were assessed by respondents in terms of their load carrying capacity: 50.0% were considered to be adequate for medium weight vehicles, 45.0% believed to be inadequate for current requirements, and 5.0% considered capable of supporting Main Battle Tanks (MBT) and other heavy platforms. The current level of capability is reasonable for simple tasks and is mainly for medium load vehicles.

The survey results reflect the KII and FGD findings, as participants reported that the Bailey Bridge and HPB-74 remain effective platforms in terms of the mobility support they offer in their respective Military Load Classification (MLC), but commanders often have to enforce vehicle movement and crossing priorities in order to prevent overloading. In fact, this rule may often lead to a formation moving at the speed of the slowest vehicle, even if the bridge could otherwise be crossed with a free-flow crossing, based on the load classes of the different vehicles. This corresponds with the authorised capabilities in the technical manuals and TO&E, suggesting the existing assets provide an adequate, though limited, level of mobility support.

**Operational Assessment of Existing Bridging Capabilities**

Overall, based on the survey, KII and FGD, the existing bridging assets are inadequate in meeting the tactical mobility needs of Infantry Divisions. The Bailey Bridge, HPB-74 and assets still serve the routine operations but are hampered by ageing equipment, a limited Military Load Classification and limited capability to cross rivers. The participants always pointed out the importance of modernisation of the inventory, as also noted by (Siddiqui, 2022; Rassel, 2022; Rahman, 2021) in support of the Bailey Bridge Manual, HPB-74 Manual, IDIB and TO&E.

**Summary**

This chapter discussed the operational environment in Bangladesh, the tactical mobility needs of Infantry Divisions in relation to the riverine terrain of the country, the organisation of Division Engineer Battalion and the technical capability of existing bridging assets as per the TO&E and relevant Technical Manuals. The results of the questionnaire survey, as well as the KII and FGD evidence, show that the current bridging assets are mostly still operationally functional, and are also able to support a reasonable level, albeit limited, of tactical mobility within their scope of operations, in support of good planning, trained personnel and maintenance. The next chapter focuses on the issues these assets are having in keeping up with current and future demands.

# Chapter III

# Challenges of Existing Bridging Assets in Meeting Present and Future Requirements

## General

Chapter II assessed the existing bridging capabilities of the Division Engineer Battalions in supporting Infantry Division mobility. Although the assets remain operationally functional at limited scale, evolving requirements, combat-platform modernization and Bangladesh's riverine terrain expose several technical and operational challenges, consistent with earlier findings (Rahman, 2021; Siddiqui, 2022).

Accordingly, this chapter analyses the challenges associated with existing bridging assets in meeting present and future operational requirements, based on the questionnaire survey, KII and FGD, supported by military doctrine, technical manuals and previous research. The findings identify technical and operational limitations and provide the basis for determining capability gaps and recommendations to enhance the tactical mobility of Infantry Divisions.

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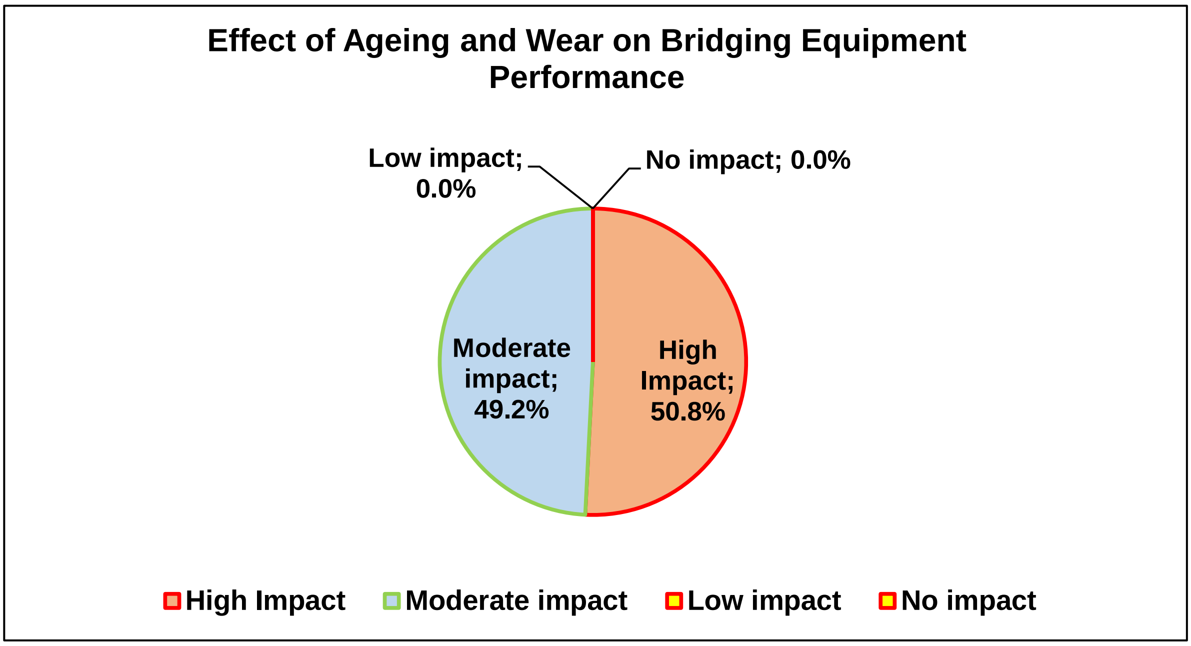
**Technical Challenges of Existing Bridging Assets**

**Effect of Ageing and Wear on Existing Bridging Assets**

**Figure 3.1**

*Effect of Ageing and Wear on Bridging Equipment Performance*




Ageing and wear directly affect operational reliability. As shown in Figure 3.1 and Table 3.1, 50.8% of respondents rated the impact high and 49.2% moderate; none reported no impact. The KII and FGD support this: Though the Bailey Bridge and HPB-74 remain operational but more frequent maintenance is needed to extend service life, consistent with the Bailey Bridge Manual, HPB-74 Manual, (Siddiqui, 2022) and (Rassel, 2022). Ageing of the bridging assets impose a significant challenge absent timely maintenance and necessary modernization.

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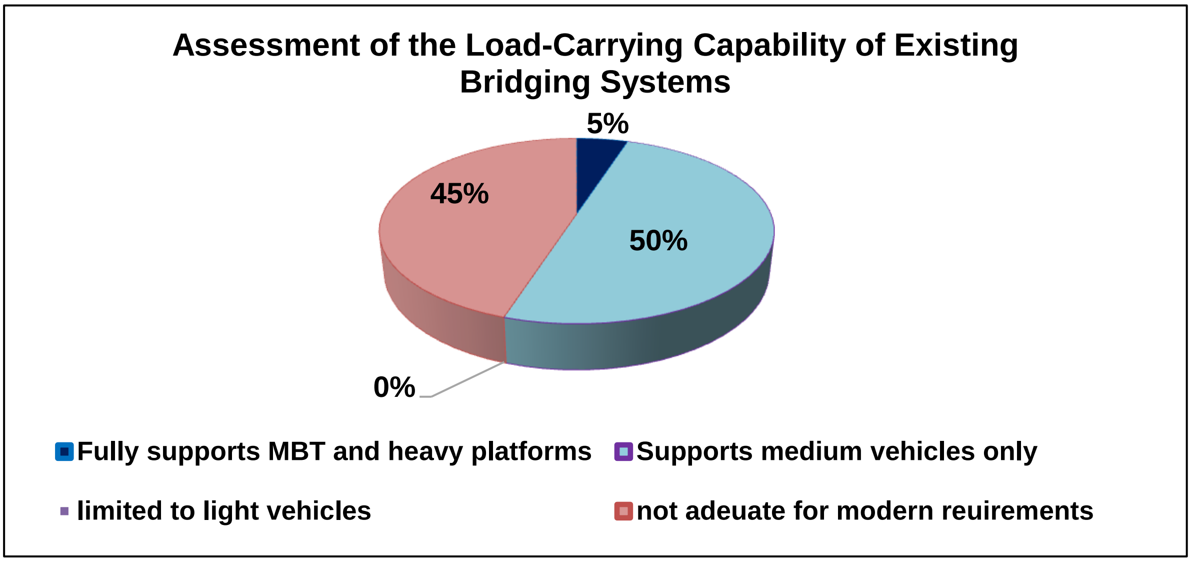
**Limitations in Military Load Classification (MLC)**

**Figure 3.2**

*Assessment of the respondents' on the Load-Carrying Capability of Existing Bridging Systems*




Military Load Classification (MLC) plays an important role to tactical mobility. As shown in Figure 3.2, among the respondents 50.0% of them reported that existing systems are adequate for medium-weight vehicles, 45.0% cosidered inadequate, and only 5.0% indicated capable of supporting MBTs. The KII/FGD confirmed the Bailey Bridge and HPB-74 perform satisfactorily within authorised MLC, but heavier vehicles need strict adherence to load regulation (Rahman, 2021; Rassel, 2022; Siddiqui, 2022). Limited MLC therefore remains a significant challenge for present and future operations.

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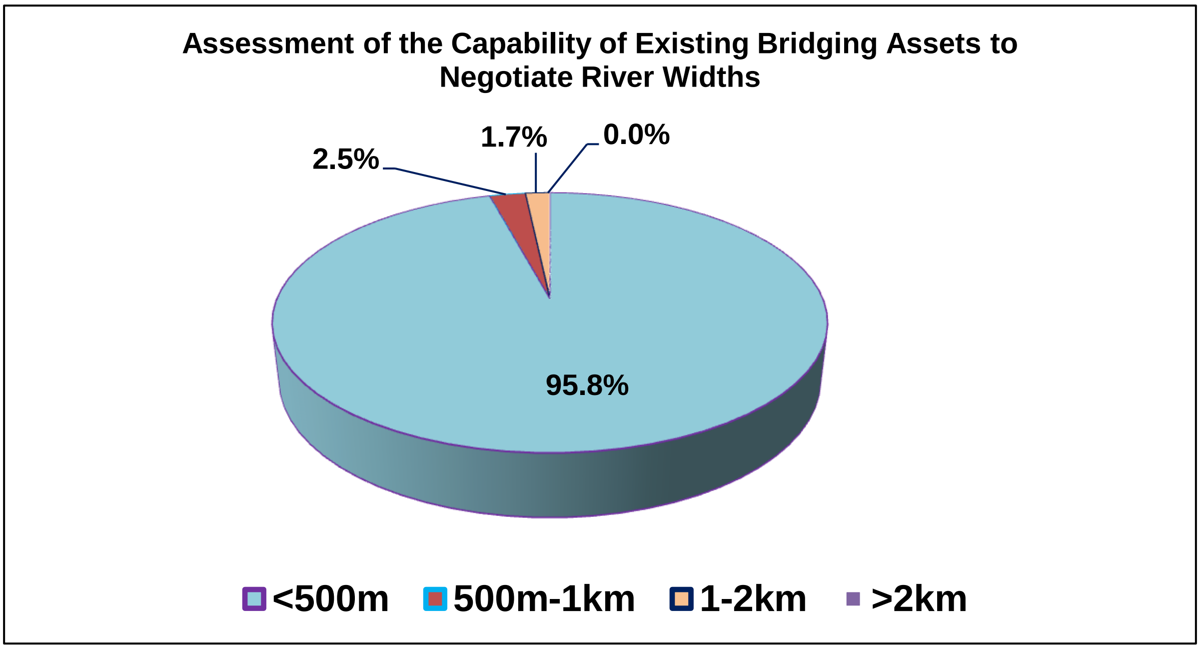
**Limitations in Negotiating Wide Rivers**

**Figure 3.3**

*Respondents' Assessment of the Capability of Existing Bridging Assets to Negotiate River Widths*




Bangladesh's river network is a significant mobility challenge. As shown in Figure 3.3, 95.8% of respondents considered existing assets incapable of negotiating rivers wider than 500 m — adequate for many situations but insufficient for major rivers. The KII/FGD confirmed wider crossings demand added resources, coordination and time (Rahman, 2021; Rassel, 2022; Siddiqui, 2022). This limited capability therefore remains a significant challenge to future mobility.

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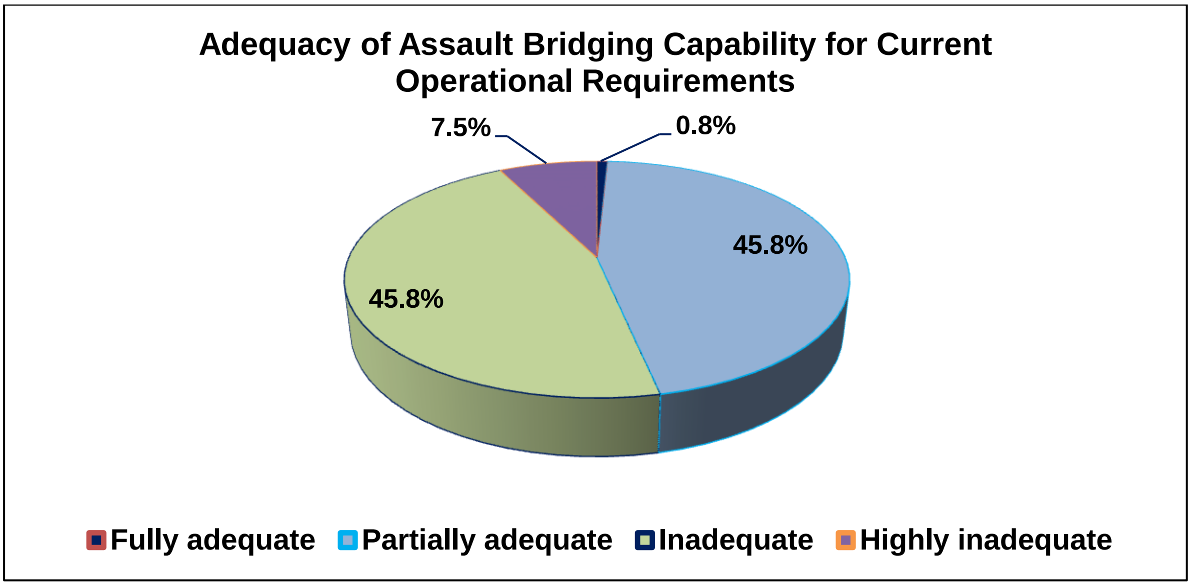
**Limitations of Existing Assault Bridging Capability**

**Figure 3.4**

*Adequacy of Assault Bridging Capability for Current Operational Requirements*




Rapid assault-bridge establishment is essential to offensive momentum. As shown in Figure 3.4, 45.8% rated capability inadequate, 45.8% partially adequate, 7.5% highly inadequate, and 0.8% fully adequate. The KII/FGD confirmed assault assets need considerable preparation time (Rahman, 2021; Rassel, 2022; Siddiqui, 2022). Improving assault bridging therefore remains a key requirement for tactical mobility.

**Operational Limitations of the Existing Pontoon System**

The KII/FGD revealed the HPB-74 continues supporting river-crossing operations but needs considerable time, manpower and logistics to deploy, particularly across wider rivers or in adverse conditions, reducing operational flexibility (Rahman, 2021; Rassel, 2022; Siddiqui, 2022; Operations of War, 2025; TO&E, 1991). Enhancing the pontoon system therefore remains essential to tactical mobility.

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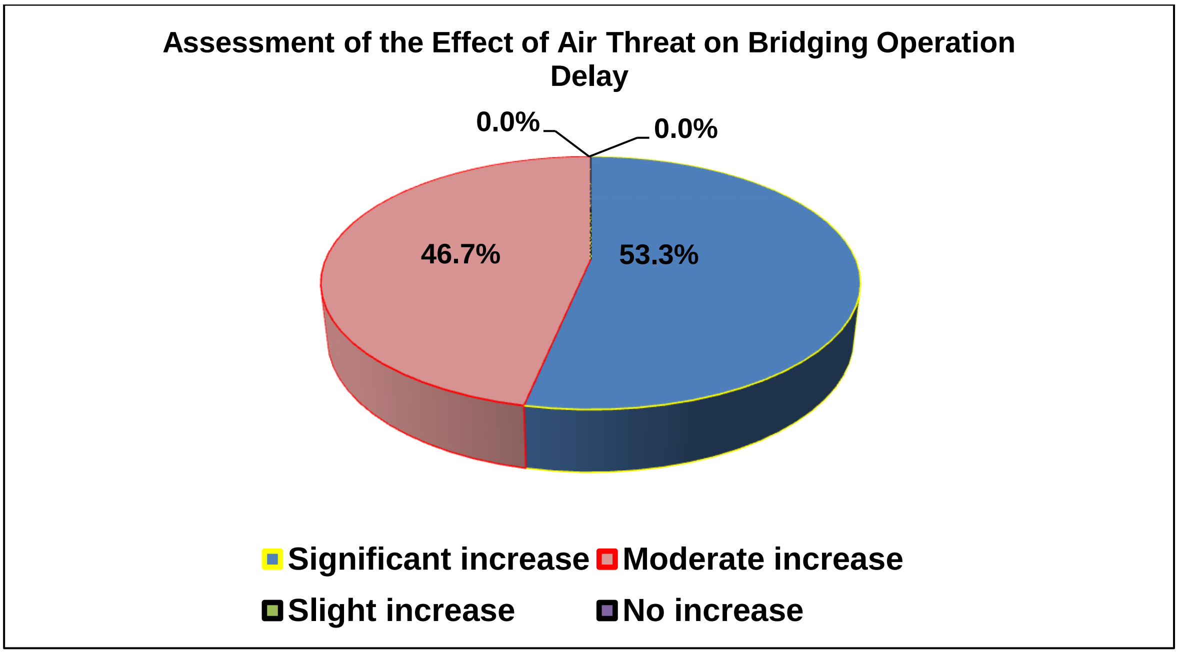
**Effect of Air Threat on Bridging Operation Delay**

**Figure 3.5**

*Respondents' Assessment of the Effect of Air Threat on Bridging Operation Delay*




Air threats are a major operational challenge. As shown in Figure 3.5, 53.3% believed air threats significantly increase delays, 46.7% moderately. The KII/FGD confirmed bridge sites are highly vulnerable to air attack and drone surveillance, and existing air-defence is inadequate against modern threats, leaving personnel and equipment vulnerable and delaying deploymen (Rahman, 2021; Rassel, 2022; TO&E, 1991; Siddiqui, 2022; Operations of War, 2025). Strengthening air-defence support is therefore necessary.

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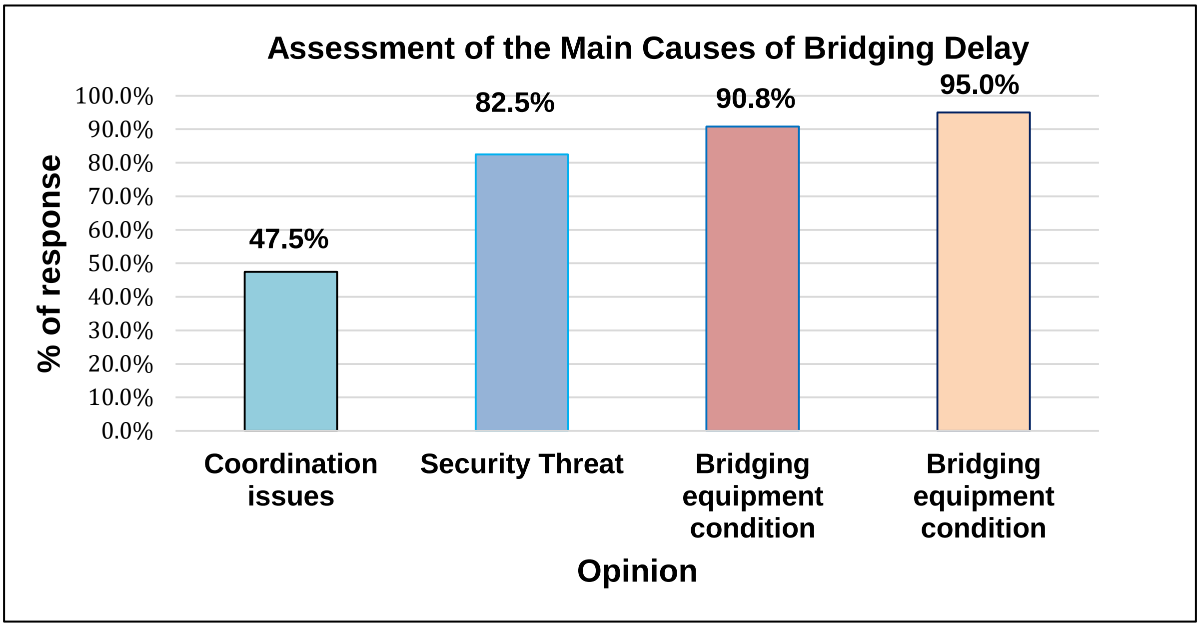
**Factors Causing Delay in Bridging Operations**

**Figure 3.6**

*Respondents' Assessment of the Main Causes of Bridging Delay*




The survey identified equipment limitation as the most frequent delay cause (95.0%), followed by equipment condition (90.8%) and security threats (82.5%); coordination issues affected 47.5%. The KII/FGD confirmed ageing equipment and slow assembly delay river-crossing, reducing operational tempo and giving the adversary time to reorganise (Rahman, 2021; Siddiqui, 2022; Rassel, 2022; Operations of War, 2025). Enhancing responsiveness is therefore essential to tactical mobility.

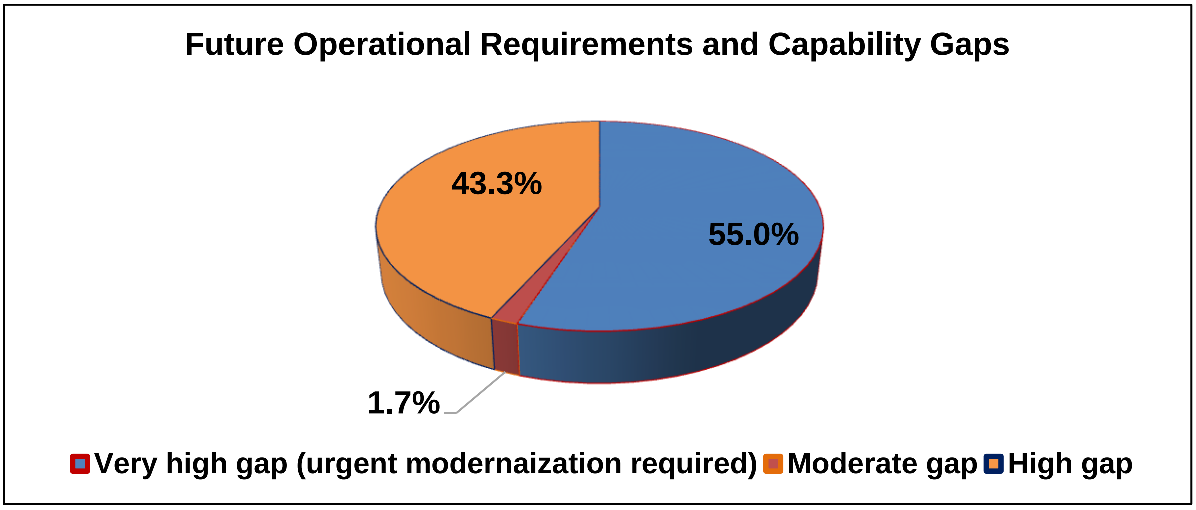
**Effect of the Existing Manual Bridging System on Tactical Mobility**

Manually operated bridging systems significantly constrain tactical mobility. The KII/FGD confirmed manual assembly of the Bailey Bridge and HPB-74 needs considerable manpower and time, intensified in adverse conditions, and units often wait for completion before continuing manoeuvre (Rahman, 2021; Siddiqui, 2022; Rassel, 2022; Operations of War, 2025). It is essential to replace manual systems with mechanised or modular equipment.

**Future Operational Requirements and Capability Gaps**

**Figure 3.7**

*Respondents' Assessment of the Level of Capability Gap Between Current Bridging Systems and Future Operational Requirements*




Future operations will require bridging systems that supports rapid manoeuvre, heavier platforms and sustained operations across Bangladesh's riverine terrain. Respondents strongly support for modernization through greater load capacity, faster deployment and operational flexibility. Although this study was originally framed against the Forces Goal 2030 benchmark but the revision of national defence priorities following the 2024 change of government, the analysis focuses on general capability gaps rather than on a strategic specific framework, which respondents were nonetheless asked about directly in the KII. The KII/FGD highlighted the essentiality for modular systems, higher MLC and improved survivability (Rahman, 2021; Siddiqui, 2022; Rassel, 2022; Operations of War, 2025).

**Gap Analysis**

The findings indicate a noticeable gap between the capability of existing bridging assets and future requirements. Although routine tasks are supported by current assets, but limitations in age, MLC, river-crossing and pontoon capacity reduce the effectiveness. Modern military operations require more than existing systems can consistently provide — capability gap has also been identified by (Rahman, 2021), (Rassel, 2022)and (Siddiqui, 2022) which is consistent with Operations of War and IDIB. Capabilty enhancement is therefore essential to ensure sustained future tactical mobility.

Among the 120 respondents, 118 were Engineer officers and 2 were Infantry officers. Among the category of rank, 87 were Majors, 28 were Lieutenant Colonels, and 5 were of ranks below Major.

**Table 3.1**

*Descriptive Statistics of Perceived Current Bridging Capability and Tactical Mobility Support*

| Analysing the Characteristics of Existing Bridging Capability | Mean | Median | Mode | Std. Deviation | Interpretation | Remark |
|---|---|---|---|---|---|---|
| Functional Status of Existing Bridging Assets | 2.01 | 2.00 | 2 | 0.21 | Agree | Existing capability remains operational |
| Load-Carrying Capability | 2.10 | 2.00 | 3 | 0.76 | Agree | Moderate operational capability |
| Impact of Equipment Ageing | 2.51 | 3.00 | 3 | 0.50 | Strongly Agree | Major operational concern |
| Adequacy of Assault Bridging Capability | 2.39 | 2.00 | 2 | 0.64 | Agree | Improvement required |
| Pontoon System Operational Adequacy | 2.45 | 2.00 | 2 | 0.56 | Agree | Limited capability |

| | | | | | | |
|---|---|---|---|---|---|---|
| Tactical Mobility Support for Infantry Division | 2.48 | 3.00 | 3 | 0.55 | Strongly Agree | Critical modernization priority |

*Note. Mean and standard deviation values are derived from SPSS Reliability Analysis (Cronbach's Alpha = .746); median and mode were computed from the corresponding frequency distributions.*

**Table 3.2**

*Binary Logistic Regression Model Summary (Outcome: Very High Capability Gap vs Moderate/High Gap)*

| **Statistic** | **Value** |
|---|---|
| Model $\chi^2$ (Likelihood Ratio) | 91.760 |
| df | 7 |
| Sig. | < 0.001 |
| McFadden's $R^2$ | 0.556 |
| N | 120 (Very high gap = 66, Moderate/High gap = 54) |
| Classification Accuracy | 90.0% (at 0.5 cut-off) |

Because Q19 is an ordinal category rather than a continuous score, instead of OLS regression binary logistic regression was employed, with the outcome collapsed into ‘Very high gap’ (n = 66) versus ‘Moderate/High gap’ (n = 54). The model is highly statistically significant overall ($\chi^2$ = 91.760, df = 7, $p < 0.001$), with McFadden's $R^2$ = 0.556 and 90.0% classification accuracy - demonstrating strong explanatory power for predicting a very-high capability gap.

**Table 3.3**

*Logistic Regression Coefficients and Odds Ratios*

| Predictor | B | SE | z | Sig. | Odds Ratio |
|---|---|---|---|---|---|
| Intercept | 0.609 | 0.357 | 1.704 | 0.088 | 1.838 |
| Load classification capability (Q2) | -0.883 | 0.466 | -1.893 | 0.058 | 0.414 |
| Ageing/wear impact (Q3) | 0.922 | 0.798 | 1.156 | 0.248 | 2.515 |
| River-width capability (Q5) | 0.444 | 0.270 | 1.645 | 0.100 | 1.559 |
| Delay effect on operational tempo (Q7) | -0.164 | 0.948 | -0.173 | 0.863 | 0.849 |
| Assault bridging adequacy (Q8) | 0.330 | 0.421 | 0.785 | 0.433 | 1.391 |
| Air defense adequacy (Q11) | -1.169 | 0.590 | -1.983 | 0.047 | 0.311 |
| Tactical mobility adequacy (Q13) | -0.226 | 0.511 | -0.443 | 0.658 | 0.797 |

Among the seven predictors, only air defense adequacy (Q11) is individually significant ($z = -1.983$, $p = 0.047$, OR = 0.311): higher-rated air defense adequacy substantially reduces the likelihood of perceiving a very high gap. Load classification (Q2) approaches significance ($p = 0.058$); the rest do not reach it — the model's strength is concentrated in few variables.

**Correlation Between Equipment Adequacy and the Perceived Capability Gap**

**Table 3.4**

*Spearman's Rank-Order Correlation Between Modernisation-Related Variables and Capability Gap*

| Variable Pair | Spearman's rho | Sig. (2-tailed) |
|---|---|---|
| Existing Bailey Bridge/pontoon system matches operational requirements vs. Capability Gap | -0.735 | < 0.001 |
| Load classification of bridging equipment matches requirements vs. Capability Gap | -0.746 | < 0.001 |
| Mobility of bridging equipment matches mobility requirements vs. Capability Gap | -0.687 | < 0.001 |

A Spearman correlation was run to directly test the hypothesis that modernisation of bridging equipment is associated with tactical mobility outcomes. As Table 3.4 shows, the capability gap (Q19) correlates strongly with three equipment-adequacy variables: Bailey Bridge/pontoon match to requirements (rho = -0.735, $p < 0.001$), load classification match (rho = -0.746, $p < 0.001$), and equipment mobility match to armoured/mechanised requirements (rho = -0.687, $p < 0.001$). The negative correlation is expected — better-aligned equipment capabilities means a smaller perceived capability gap — the correlation provides direct statistical evidence supporting the hypothesis using a test appropriate to ordinal data.

**Summary**

This chapter examined the challenges associated with existing bridging assets in meeting present and future operational requirements. The findings identified limitations including ageing equipments, restricted MLC, limited river-width capability, inadequate pontoon capacity and operational constraints. Although existing assets continue supporting current operations, there is necessity of modernization to sustain tactical mobility; the identified gaps provide the basis for the recommendations presented in next chapters.

# Chapter IV

# Enhancing Bridging Capabilities of Division Engineer Battalions for Desired Tactical Mobility of Infantry Division

## General

Chapters II and III have already laid out the background for the current state of the DEB bridging equipment and the problems that this represents to Infantry Division's tactical mobility. The Bailey Bridge and HPB-74 still work within their authorised limits, but river-width, MLC and air-defense shortfalls drive the capability gap that found in Chapter III (Table 3.3; Table 3.4). So, there is no alternative to the structured modernization. This chapter puts forward a Tiered Bridging Capability Enhancement Model consists of sustainment, augmentation, and layered air-defense integration.

## Future Operational Requirements

Several of the questions in the survey were "future" questions and have not been analysed in earlier chapters. These results are reported in this section as the factual background for analysis in this chapter.

**Figure 4.1**

*Respondents' Preferred Future Bridging System Approach (Multi-Select)*

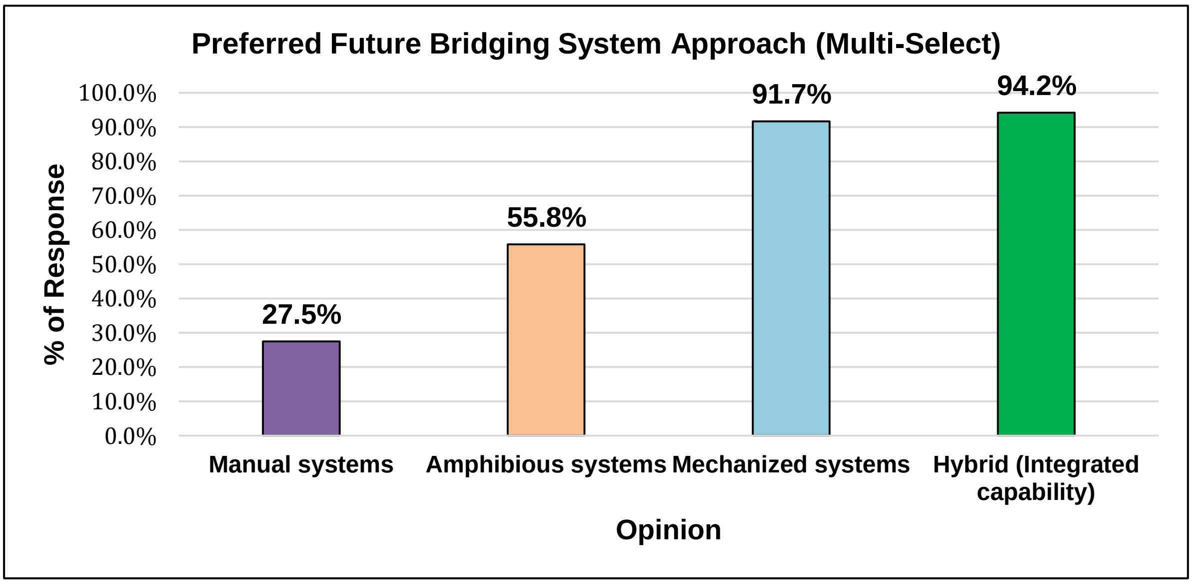



Figure 4.1 shows that 94.2% of the respondents were in favour of a hybrid, integrated approach, while 91.7% of the respondents favored mechanized systems, indicating a move away from manual assembly. Senior Engineer KII also opined that future systems require quick turn around, mobility tracking, protection and amphibious ability at the same time, not any one alone. The KII concluded that

Bangladeshi soil and topography is not fully favoring a wheeled system and it is recommended to use tracked configuration for Bangladesh's cross country mobility requirement.

**Figure 4.2**

*Respondents' Priority for Modernization (Multi-Select)*

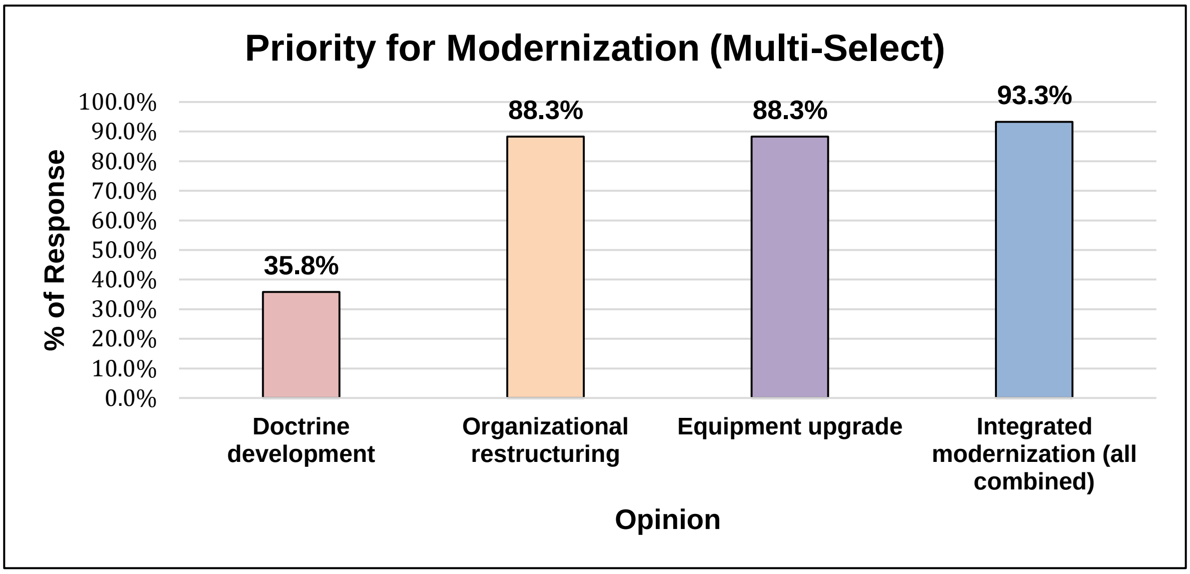



Figure 4.2 shows that 93.3% of the respondents gave high importance to integrated modernization, rather than any single-track approach. 88.3% chose equipment upgrade and 88.3% chose organizational restructuring. This is in line with the Senior Engineer KII who stated that the doctrine must be with the equipment change, not behind it.

**Figure 4.3**

*Respondents' Critical Future Requirements (Multi-Select)*

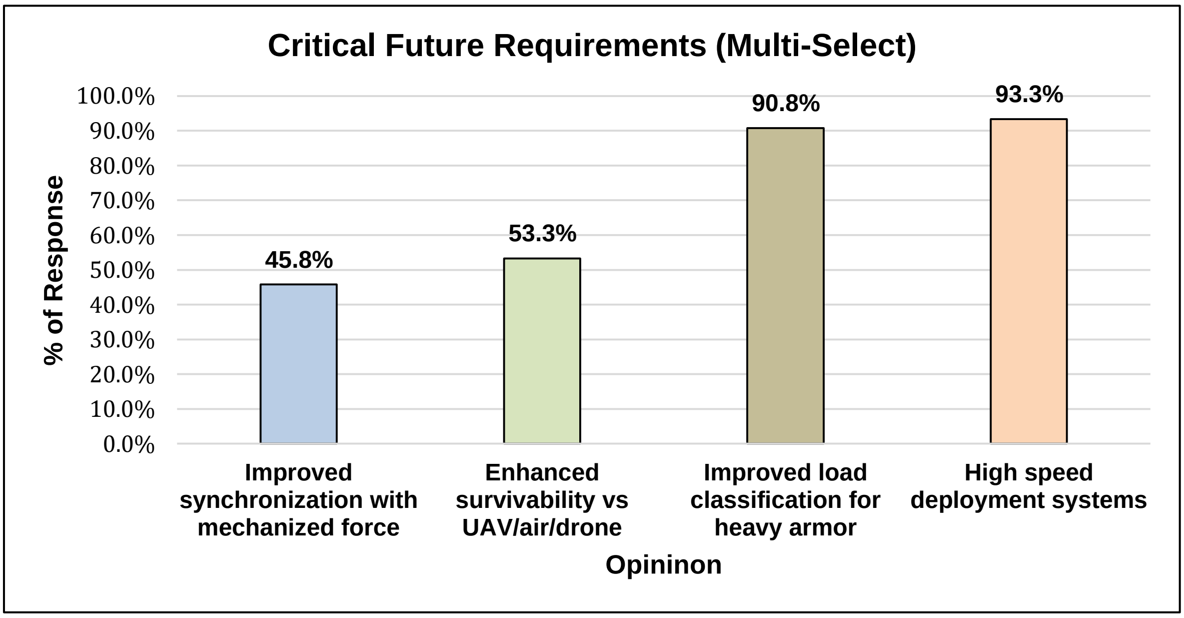


Figure 4.3 shows, respondents ranked high-speed deployment (93.3%) and improved load classification (90.8%) as the top future needs, with survivability against UAV and drone attack cited by 53.3%. This lines up with the regression finding in Chapter III (Table 3.3), where air defence adequacy was the only significant predictor of the capability gap.

Other open-ended responses showed specific equipment respondents felt they needed the AVLB, amphibious pontoon rigs and the combat engineer vehicles, all of which came from the study's own data in corroboration with (Rassel, 2022)'s recommendation. The priorities were slightly different across groups where the Senior Engineer KII identified mobility and speed take priority, and the FGD said speed is priority, load capacity second, survivability and mobility integration third.

**Basis for Modernization**

The study was initially framed against Forces Goal 2030; as described in Chapter III, this was updated in 2024. The basis of this roadmap is are not dependent on just any single plan rather on the the study's own data (see Table 3.3, Table 3.4); the Armoured Regiment and Mechanized Infantry Battalion's upgradation (Rassel, 2022), which is already a completed fact that also requires mobility; global trends in unmanned aerial threats; and comparative regional practice, which demonstrates the gap is widening and not dependent on the status of any plan. The Senior Engineer KII noted the existence of an on going plan for modernization within the Corps of Engineers which is also focused on modernization of the bridging assets of DEB.

**The Tiered Bridging Capability Enhancement Model**

This study suggests a Tiered Bridging Capability Enhancement Model (Figure 4.4) instead of complete overhaul and an unmodified status quo based on Chapters II and III. The Senior Engineer KII was clear; it isn't feasible, in either time or money, to do the whole overhaul, and modernization has to be staged, with legacy systems serving where possible.

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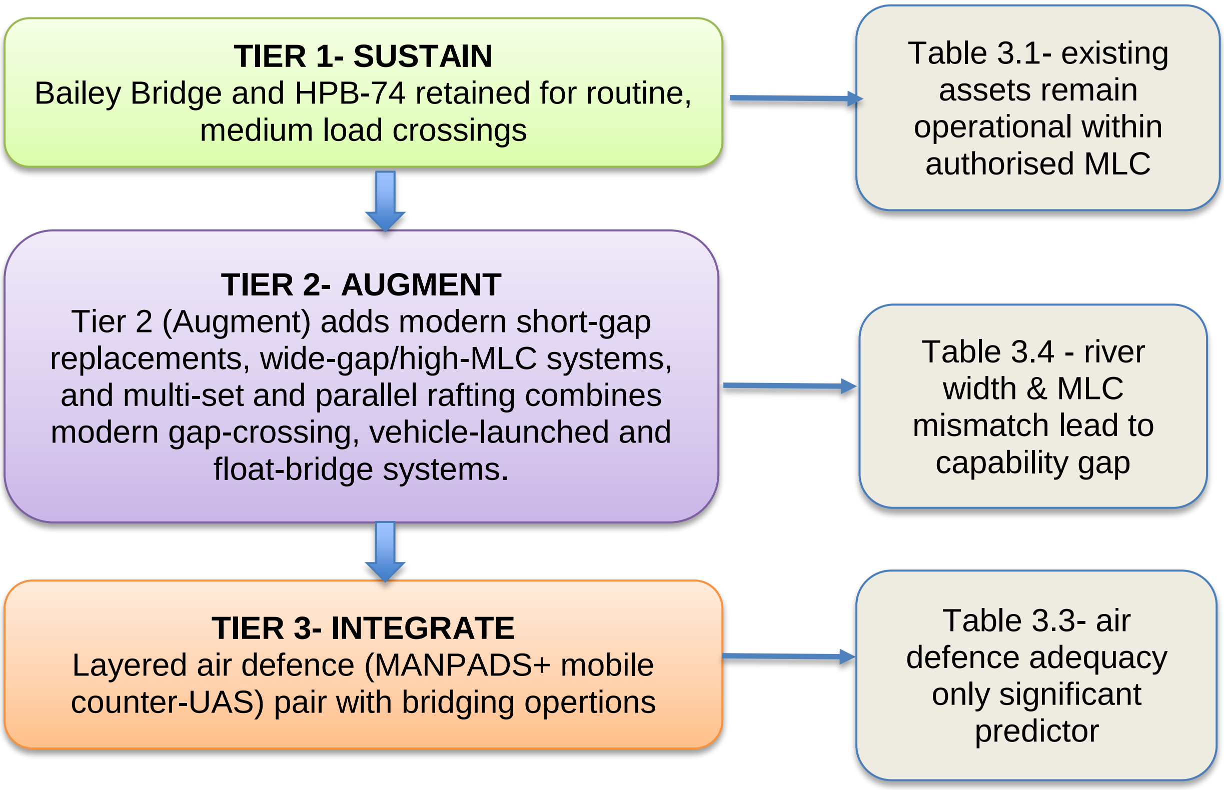
**Figure 4.4**

*Tiered Bridging Capability Enhancement Mode*




Tier 1 (Sustain) keeps the Bailey Bridge and HPB-74 with routine to medium load crossings as Table 3.1 showed that these assets are still being used within the authorised limits. Tier 2 (Augment) brings in wide-gap, high MLC system along with multi-set and parallel rafting, addressing the river width and load constraints identified in chapter III, Table 3.4. Tier 3 (Integrate) includes additional air defence layers, targeting the strongest predictor of capability gap in the logistic regression identified in Table 3.3.

The model is built around geography differentiation. Large rivers such as The Jamuna, Padma and Meghna cannot be crossed with a single bridge available with DEB. Again with moderate width rivers the HPB-74 (91 metres) is too short, but more sets will make it up to the standard. But the manageable rivers remain adequately served with existing bridges. This supports Table 2.1 that revealed AOR characteristics vary across Infantry Divisions with no variation in resources. Senior Engineer KII also indicated that the requirements vary across terrain, organic composition of Infantry Divisions and their operational role.

**Recommended Systems by Tier**

Based on the data presented in this study, open source literature and (Rassel, 2022), the recommended systems for each tier are summarised in Table 4.1.

(Rassel, 2022) found that DEB is restricted to quarter-sets in the T-74/HPB-74 and suggests that there should be one more set for 300-metre gaps, making the tiering above concrete.

**Table 4.1**

*Recommended Systems by Tier*

| Tier | Category | Recommended System(s) | Source |
|---|---|---|---|
| 1 - Sustain | Existing short-gap | Bailey Bridge, HPB-74 (continue and Focuse on sustainment) | Bailey Bridge Manual, (HPB-74) |
| 2 - Augment | Modern short gap alternative | Medium Girder Bridge (MGB), self-launching bridge-layer (Wolverine / AVLB type) | US Army (n.d.), Army Recognition (n.d.) |
| 2 - Augment | Wide-gap and high-MLC | M3 Amphibious Bridge, PFM Motorized Floating Bridge (CNIM), Acrow 700XS, DRDO Sarvatra | GDELS (n.d.), CNIM (n.d.), Acrow Bridge (n.d.), DRDO (n.d.) |
| 2 - Augment | Mechanized bridging (Mechanized Force specific) | AVLB / BLT (self propelled, amphibious) | (Rassel, 2022) |
| 2 - Augment | Large river negotiation | Multi set combination and parallel rafting, Ribbon/M4T6-type rafting, Assistance | US Army (n.d.); Senior Engineer KII |

| | | | |
|---|---|---|---|
| | | from Riverine Engineer Battalion assets | |
| 3 - Integrate | Layered air defence | MANPADS (larger aerial threats) and mobile counter-UAS, MADIS-type (small drones) | Army Recognition (n.d.), Missile Defense Advocacy Alliance (2022), AUSA (2024) |

**Table 4.2**

*Recommended System Specifications*

*Specifications below are drawn from the sources cited in each row; full citations are given in the Chapter IV reference list.*

| System | Span / Length | Load Capacity (MLC) | Deployment Time | Configuration | Source |
|---|---|---|---|---|---|
| Bailey Bridge (existing) | 80 ft (authorised set) | Class 40 | 6 hours (manual assembly) | Manual and towed | Bailey Bridge Manual, (Rassel, 2022) |
| HPB-74 (existing) | 91 m | Class 50 | 1 hour (Manual assembly) | Manual and towed | (HPB-74) |
| M3 Amphibious Bridge (GDELS) | 100 m | Class 50 - 60 | 15 minutes | Self propelled, trackedand amphibious | GDELS (n.d.), Army-Technology (2025) |
| Motorized | 100 m | MLC 90T / | 30 minutes | Self propelled | CNIM |

| | | | | | |
|---|---|---|---|---|---|
| Floating Bridge (CNIM) | bridge | 100W | | and amphibious | (n.d.) |
| DRDO Sarvatra (India) | 15–75 m span | MLC 60 - 70 | Not specified | Truck-mounted and wheeled | DRDO (n.d.) |
| Self-Launching Bridge Layer (AVLB / BLT-type) | 25 m | MLC - 70 (AVLB - type) | 2 minutes | Self-propelled and tracked | (Rassel, 2022) |

According to Russell and Thrall (2012), modern bridges can be broadly categorized as gap-crossing, vehicle - launched (AVLB, Dry Support Bridge), float and causeways. Tier 1 is the legacy gap crossing tier, Tier 2 is the vehicle - launched and float-bridge tiers recommended here. The construction time disparity is large as (Rassel, 2022) reported the existing 80 foot Bailey Bridge requiring about six hours, whereas the BLT/AVLB 25-metre span needs only two minutes. Moreover, it is recommended that a Combat Engineer Vehicle (Trojan AVRE, Russian IMR, or American M728) also be used for river-bank preparation as per (Rassel, 2022), even if the bridging capacity is sufficient, the unprepared river-bank is still a problem.

The large river crossing is not a one 'bridge' solution. The rivers like the Jamuna and Padma are wider than a single set and the approach established so far (US Army FM 90-13) combines multiple sets with parallel rafting across dispersed sets. The KII also pointed towards the fact that the Riverine Engineer Battalion’s (REB) vessels can also be used to supplement DEB without any procurement during operational need

**Organizational Considerations**

The Senior Engineer KII identified the requirement of structural changes in the DEB. The equipments of the bridge company should not be fixed uniformly across all Infantry Divisions. Bridge Companies should be equipped according to the terrain and operational plan of the Infantry Division it supports. For example, 91 metre HPB-74 capacity should be revised as per the terrain and operational requirement.

Regarding the capacity of reserve, the KII said that the DEB of 14 Independent Engineer Brigade is a de facto reserve but not fully adequate to meet operational requirement. (Rassel, 2022) also said that this Battalion is no different from the other DEB, and will not be able to support the Army Reserve. Resources are unevenly distributed between the Division nominated as Army Reserve and others, which results in a lack of support; reserve assets should be planned based on the operational plan.

**Training and Sustainment**

The FGD group identified not only equipment issues, but also included limited combined-arms training facilities, shortage of specialist operators and lack of joint exercises which are the best way to find out the real limitations. When it comes to air defence, the only equipment available is the organic machine gun of the bridge company, which are not good enough against modern UAV and precision threats. So, Tier 3 is a new capability and not an incremental one. The FGD also found that DEB has no organic recovery capacity and relies on the Divisonal EME company which has limited spare parts and it is consistent with the findings of Chapter II. The measures that follow directly are joint exercises, a specialist operator career track, organic recovery capability, and a preventive maintenance cycle for OBM systems that follows the pattern of failure recorded by (Rassel, 2022).

**Comparative International Practice**

(Iyer, 2024) noted that armies to treat wet gap crossing as a priority, not as a legacy capability, citing the challenges faced by Russian forces in crossing the Siverskyi Donets River in 2022. (Mills, 2023) extends this to riverine capability in general, where many river and bridge structures have been the determining factors on the battlefield in recent wars.

Comparative practice with armies with terrain environment similar to Bangladesh riverine environment is summarized in Table 4.3.

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**Table 4.3**

*Comparative International Bridging Practice*

| Country/ Force | System | Relevance to Bangladesh (Source) | Span / Length | Deployment Time | Terrain Suitability |
|---|---|---|---|---|---|
| NATO / Germany, Norway, UK | M3 Amphibious Bridge and Ferry System | 100m bridge in under 15 minutes, MBT-capable (GDELS, n.d.) | 100 m | 15 minutes | Suited, Amphibious, comparable wet gap profile |
| France | PFM Motorized Floating Bridge | MLC 90T/100W, 100m bridge in under 30 minutes, no crane required (CNIM, n.d.) | 100 m | 30 minutes | Suited, no crane/earthmover needed, fits limited-infrastructure sites |
| India | DRDO Sarvatra Multi-Span Mobile Bridging System | Truck-mounted, MLC 60-70; developed for terrain comparable to Bangladesh (DRDO, n.d.) | 15–75 m | Not specified | Well suited, designed for comparable riverine/high-altitude terrain |
| India | 46 metre Modular Bridge (2024) | Most recent regional precedent; mechanically-launched, rapid retrieval (Army Recognition, 2024) | 46 m | Rapid (exact figure not published) | Suited to moderate rivers |

| | | | | | |
|---|---|---|---|---|---|
| China | HZ21 (NORINCO/CHIC) | Alternative to Bailey-type systems (MilitaryLeak.com, 2022) | Not publicly specified | Not publicly specified | Export-market system; suitability for BD terrain not independently verified |
| China | Self propelled amphibious bridging vehicle | Comparable wide gap self-propelled alternative (Army Recognition, 2020) | 13 m x 20 m pontoon platform | 3 minutes | Suitability for BD terrain not independently verified |

The DRDO Sarvatra system is relevant (DRDO, n.d.), a neighbouring army designed a similar system for a similar terrain. China's HZ21 and its self-propelled amphibious vehicle offer a further comparison which is included in Table 4.3. Based on the modelling of (Rassel, 2022) and considering a Mechanised Force at 30km/h, it is observed that a self-propelled amphibious bridge can provide a delay time of 2.5 hours for 622km of travel.

**Cost-Benefit Considerations**

The HPB-74 designation and (Rassel, 2022)'s mention of the T-74 pontoon bridge however, indicates that it is a 1974 design, and probably in use for over 50 years. This coincides with the 50.8% high ageing-impact rating in Table 3.1 and the FGD's comments on an approved capacity of 91 metres, but this is not reflected fully on the ground.

Since there are no costed procurement data, Table 4.4 makes a qualitative comparison which underpins this chapter's phased approach.

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**Table 4.4**

*Cost-Benefit Framework: Modernization versus Status Quo*

| Dimension | Cost of Modernizing | Cost of Not Modernizing |
|---|---|---|
| Direct | Procurement, training and integration costs | Continued high maintenance cost on an ageing fleet |
| Operational | Transition period capability dip during fielding | On going capability gap (Table 3.2) |
| Risk | Limited if phased and geography sequenced | Casualty and mission-failure risk during river-crossing delays (Rassel, 2022) |
| Strategic | Alignment with regional peers | Widening capability gap relative to comparable armies (India's Sarvatra/Modular Bridge programmes) |

This approach favours a phased approach. The advantages of modernization outweigh the status quo from operational, risk and strategic considerations. The phased approach is more advantageous from a direct cost perspective, which is echoed by Senior Engineer KII's concerns about budget and time feasibility.

**Validation Requirement**

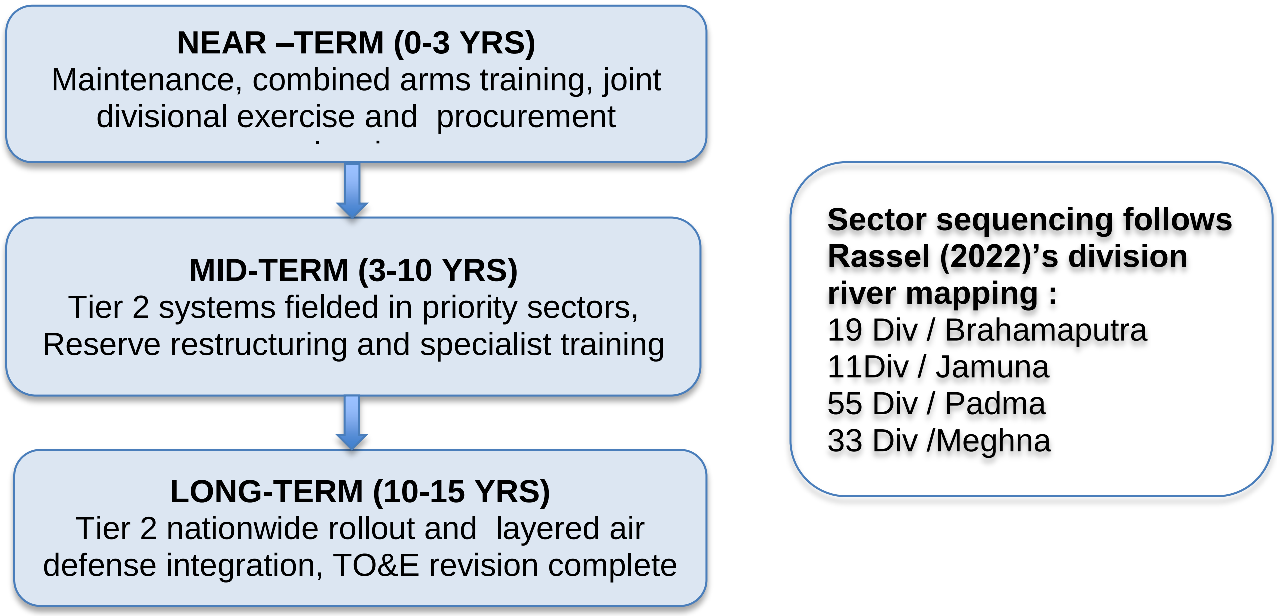
At present, Infantry Divisions seldom carry out a full river-crossing exercise with all echelon with the DEB. This study proposes such divisional joint exercises. It was not a question put to the respondent rather it is the researcher's own suggestion. However, the FGD supports it. FGD prticipants said that regular exercises are the only way to find real limitations. They also confirmed that forces waiting at crossing points face air attacks and precision strikes which cause both casualties and loss of tempo. The exercises would test bridging capability under real operational pace.

**Phased Implementation Roadmap**

The proposed phasing is shown in figure 4.5. As the equipment gets modernized in parallel throughout the three phases, air-defense integration becomes part of the fold as Tier 2 becomes the norm.

**Figure 4.5**

*Phased Implementation Roadmap*




Equipment modernization runs continuously across all phases: air defense integration follows once Tier 2 assets are fielded. Alongside each Division's river width and MLC data should be given mid term priority, rather than a uniform rollout.

**Summary**

This chapter has suggested the Tiered Bridging Capability Enhancement Model which suggests maintaining existing assets, enhancing with wide gap systems and high MLC systems, and then introducing layered AD systems. Concept og the geography differentiated tiering, organizational consideration, training and sustainment, and a phased roadmap sequenced by Division were presented, drawing on findings from this study's KII and FGD, comparative practice, and (Rassel, 2022). To validate the concept, a divisional joint exercise was suggested as an initial short-term step. The findings are used in the recommendations in Chapter V.

# Chapter V

# Conclusions and Recommendations

## Conclusions

Tactical mobility is a basic requirement for the effective employment of an Infantry Division, and the ability of the DEB directly affects manoeuvre continuity in Bangladesh's predominantly riverine environment. This study was undertaken to evaluate the effectiveness of the existing bridging capabilities of DEB in supporting the tactical mobility of Infantry Divisions and to determine measures for enhancing this capability against present and future requirements.

In Chapter II, the research examined the present capacity of existing bridging assets of DEB. It was noted that the Bailey Bridge and HPB74 are still partially operational within their authorised limits. The majority of the respondents (95.8%) found existing assets to be partially functional due to wear and tear, 2.5% were functional with some minor limitations; and 1.7% found that existing assets were non-functional or needed a major repair. Regarding load classification, only 5.0% of respondents believed existing assets would be able to handle MBTs, 50.0% said the existing assets would only meet medium weight requirements, and 45.0% said the existing assets would not meet the current requirements. It was also determined that the DEB's authorisation to bridge is not terrain dependent, although there is large variation in AOR river density and width between Infantry Divisions.

The researcher identified challenges of current bridging assets in fulfilling current and future tactical mobility requirements of Infantry Divisions in Chapter III. The major problems identified from the Survey, KII and FGD were the lack of ability to negotiate rivers wider than 500 metres (4.2% respondents) and the inadequacy of the integration of air defence (53.3% respondents). The most common causes for bridging delay were equipment limitation (95.0%) and equipment condition (90.8%) over security threats (82.5%) and coordination issues (47.5%). These challenges were validated statistically, and a binary logistic regression analysis showed that only air defense adequacy was an individual predictor of a very-high perceived capability gap (McFadden's $R^2 = 0.556$).

Based on the results, the researcher identified a modernization roadmap for DEB in Chapter IV to address the obstacles and improve the bridging capability of DEB. A Tiered Bridging Capability Enhancement Model was recommended, based on the findings described in Chapter 3, with three tiers: sustain existing assets for routine activities (Tier 1), augment with wide-gap and high-MLC systems and multi-set rafting for major rivers (Tier 2), and integrate layered air defense (Tier 3). The model was found to be different across the Infantry Divisions and further informed by comparing with international practice, such as the DRDO Sarvatra system of India, the M3 Amphibious Bridge of NATO and the HZ21 system of China, besides by the FGDs carried out during this study for the model.

Besides qualitative validation from KII and FGD, a Spearman's rank-order correlation and a binary logistic regression were also carried out to validate the research hypothesis. It was found that the perceived capability gap strongly and significantly correlated with the equipment-adequacy variables (all variables significant at the $p < 0.001$) as follows; existing systems matching operational requirements (rho = -0.735), load classification matching requirements (rho = -0.746), and equipment mobility matching armoured/mechanised requirements (rho = -0.687). Logistic regression confirmed air defense adequacy as a significant predictor of the perceived capability gap. Therefore, based on descriptive analysis and inferential analysis, the researcher accepts the hypothesis that modernization of bridging equipment of DEB has a significant effect on the tactical mobility of an Infantry Division in terms of both current and future needs.

**Recommendations**

Based on the gained results of the research, the following recommendations are presented along the sequence of the near-term, mid-term and long-term roadmap set forth in Chapter 4 for improving the bridging capability of DEB:

***Sustainment of Existing Assets (Tier 1)***

Engineers Directorate, Army Headquarters to Implement Formal Preventive Maintenance Cycle for Bailey Bridge and HPB-74 Assets by June 2027.

Engineers Centre and School of Military Engineering (ECSME) to review training curriculam to ensure maintenance of current levels of proficiency as the fielding of Tier 2 systems continues through to December 2026.

***Augmentation with Wide-Gap and High-MLC Systems (Tier 2)***

By December 2027, Engineers Directorate to start feasibility study and procurement process for the wide gap, high-MLC bridging systems and the self-launching short gap bridging systems based on the comparative international systems identified in Chapter IV.

By June 2028, Engineers Directorate to complete the doctrine for multi-set combination and parallel rafting for large river crossing (Jamuna, Padma and Meghna); and review the capability of the Riverine Engineer Battalion for interim augmentation of DEB.

***Integration of Layered Air Defense (Tier 3)***

The Engineers Directorate should have a program of modernization of the existing anti-aircraft machine gun to make it compatible with a larger threat, i.e. MANPADS, and also provide mobile counter-UAS systems to deal with small drones, working in conjunction with the Air Defense Directorate. Integration of these together would form a layered air defense for bridging operations which is to be completed by June 2029.

***Organizational and Training Measures***

By December 2026, Engineers Directorate to update the TO&E for Bridge Companies to allow for division specific equipping based on the terrain and operational need as opposed to a uniform rate across all of DEB.

The Corps of Engineers to review and upgrade the bridging capability within the Army Reserve, in anticipation of the operational plan.

By June 2027, ECSME to create a dedicated career path and training pathway for operators.

***Validation***

Military Operations Directorate and Military Training Directorate to direct the conduct of divisional-level joint river-crossing exercise, involving the Infantry Division with its mechanised and armoured elements and the supporting DEB, as a validation mechanism, with the first exercise conducted by December 2027 and an annual cadence thereafter.

***Long-Term Option***

The Corps of Engineers to discuss with the Directorate General of Defence Purchase and BMTF the possibilities of indigenous/licensed production of certain types of bridging equipment in the future, so as to reduce procurement cost and reliance on foreign sourcing.

**Scope for Further Research**

Further research can be carried out on the following issues as found out by the researcher:

Studies can be carried out on the validity of this Tiered Bridging Capability Enhancement Model, specifically in relation to Mechanized Force requirements.

A complete costed modernization plan can be pursued at a later date, once data on procurement and manufacturer service-life records is available for DEB bridging equipment.