

Whitepaper

Total cost of ownership



Content

Preface -----	3
About us -----	3
Introduction -----	4
What is total cost of ownership? -----	6
Why does total cost of ownership matter? -----	6
Building a predictable total cost of ownership -----	8
Initial investment.....	8
Operational costs.....	11
Maintenance and service	11
Conclusion -----	15

Preface

This document is intended for Ministries of Health (MoH), National Tuberculosis Programs (NTP), non-governmental organizations, and private healthcare providers in the planning, procurement, and implementation of chest X-ray-based screening approaches for active TB, broader lung health assessment, and triage in resource-constrained settings.

As countries prepare new investments in TB screening through the current Global Fund Grant Cycle and other donor-funded programs, procurement decisions are increasingly expected to demonstrate not only technical performance, but also long-term “value for money” and operational sustainability. Understanding the total cost of ownership of screening solutions has therefore become an important part of planning realistic budgets, supporting sustainable screening programs, and making informed investment decisions.

Total Cost of Ownership (TCO) is a financial estimate that calculates the direct and indirect costs of a solution over its entire lifetime, not just the initial purchase price.

The total cost of ownership approach allows countries to evaluate solutions across acquisition, deployment, operational, and end-of-life costs. This document outlines how our integrated digital X-ray and CAD4TB+ solutions can support the budgeting and predictability of programmatic costs.

About us

Delft Imaging develops and delivers diagnostic imaging solutions tailored to the needs of health systems in vulnerable and resource-constrained settings. Since 2002, we have focused on assisting healthcare programs through accessible and sustainable technologies.



90+

countries



3,200+

installations



4.3K+

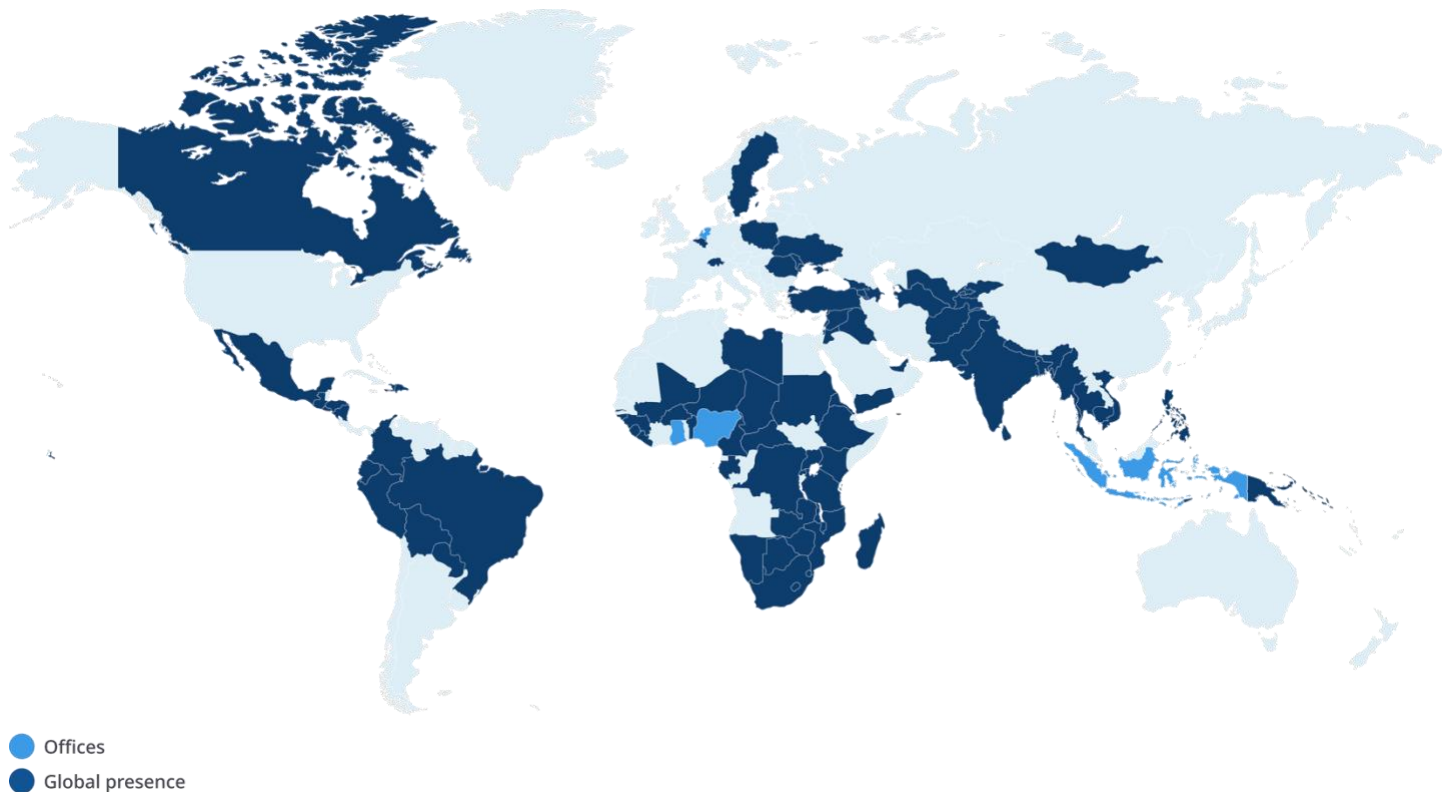
capacity building



55+

million impact

With roots in the Netherlands’ first radiology equipment factory (ENRAF), our work builds on a century of experience in medical imaging. Over the decades, we have expanded our expertise through international partnerships and field-based implementation.



Introduction

Tuberculosis remains a major global public health challenge, with an estimated 10.7 million people developing TB and 1.23 million deaths reported in 2024. Following disruptions during the COVID-19 pandemic, global case notifications have recovered, with a record 8.3 million people with TB notified in 2024.¹ Despite this progress, gaps in timely diagnosis remain, particularly in high-burden and resource-constrained settings with key and vulnerable populations.

There is increasing evidence that passive case-finding alone will not be sufficient to close the remaining diagnostic gap. Many people with TB lack symptoms, do not recognize their symptoms, experience only mild symptoms, or do not seek healthcare until the disease has progressed. As a result, National TB Programs and implementing partners are placing greater emphasis on systematic screening and active case finding to timely identify people who would otherwise remain undiagnosed.

Chest X-ray has long been an important part of the TB diagnostic pathway and is increasingly being used to support systematic screening. In addition to identifying people with presumptive TB, chest X-ray can contribute to broader lung health assessment as programs expand screening beyond TB alone. However, implementing chest X-ray-based screening requires basic infrastructure and appropriately trained personnel to acquire and

¹ World Health Organization. Global Tuberculosis Report 2025.

interpret images, resources that remain limited in many low- and middle-income countries. These implementation requirements should also be considered when planning sustainable screening programs.²

In response to these challenges, Delft Imaging developed solar-powered, stationary, mobile, and ultra-portable X-ray systems with seamlessly integrated artificial intelligence (CAD4TB+) to accurately detect and quantify abnormalities suggestive of TB in chest radiographs.

Expanding screening programs requires investment in equipment, implementation, and operational support. While digital chest X-ray systems represent a relatively high upfront investment, these costs should be considered over the operational lifetime of the equipment. When appropriately utilized, maintained, and supported, the initial investment can depreciate over years of operational life and the number of screenings, providing a complete picture of the resources required to sustain screening services.

At the same time, many programs operate in increasingly constrained environments, with growing pressure to reduce costs and make better use of available resources.^{3 4} This is particularly relevant as governments and implementing partners seek to maximize the impact of finite funding while expanding access to systematic screening and active case-finding.

As programs expand screening with finite budgets, procurement decisions need to look beyond the purchase price and consider the full cost throughout their operational lifetime. This paper aims to provide greater transparency around these cost drivers, helping countries and implementing partners better understand and plan for the total cost of ownership of TB screening programs.

² Bashir S, Kik SV, Ruhwald M, Khan A, Tariq M, Hussain H, Denking CM. (2022). Economic analysis of different throughput scenarios and implementation strategies of computer-aided detection software as a screening and triage test for pulmonary TB. PLOS ONE, 17(12), e0277393.

³ World Health Organization. Monitoring the Impact of Funding Cuts on TB Services (2025).

⁴ Yassin MA, Rashid A, Wandwalo E. Can We Optimize the TB Response Amid Funding Constraints Using Evidence-Based, Cost-Effective Strategies? (2025).

What is total cost of ownership?

Total cost of ownership (TCO) refers to the total cost of procuring, operating, and maintaining a system throughout its operational lifetime. While the purchase cost represents the initial investment, it is only one component of the overall cost of ownership.

Why does total cost of ownership matter?

Procurement decisions often focus on these initial, upfront costs. However, below the surface are the recurring costs associated with implementing, operating, and maintaining a solution over time. These include costs such as training, preventive maintenance, technical support, software updates, and replacement of faulty parts. Together, these initial costs determine the total cost of ownership and should be considered when planning the overall budget.

In screening programs, total cost of ownership provides a more complete understanding of the resources required to implement and sustain screening services over the equipment's operational lifetime. This provides a more realistic basis for estimating the total budget required for long-term program sustainability.

As funding becomes increasingly constrained, understanding the full cost of ownership has become an important part of planning. Considering both the initial investment and the recurring operational costs enables programs to better estimate the total budget required for the long-term operation and maintenance of screening solutions. According to healthcare asset management benchmarks and capital equipment procurement standards, operational overhead and support costs over a standard 7-to-10 year radiology asset lifespan regularly reach up to 100% of the initial capital expenditure.⁵

⁵ Healthcare Financial Management Association. (2021). *Total cost of ownership models for diagnostic imaging technology capital procurement* [White paper]. HFMA Asset Management Resources.

Acquisition cost is only part of the total cost of ownership

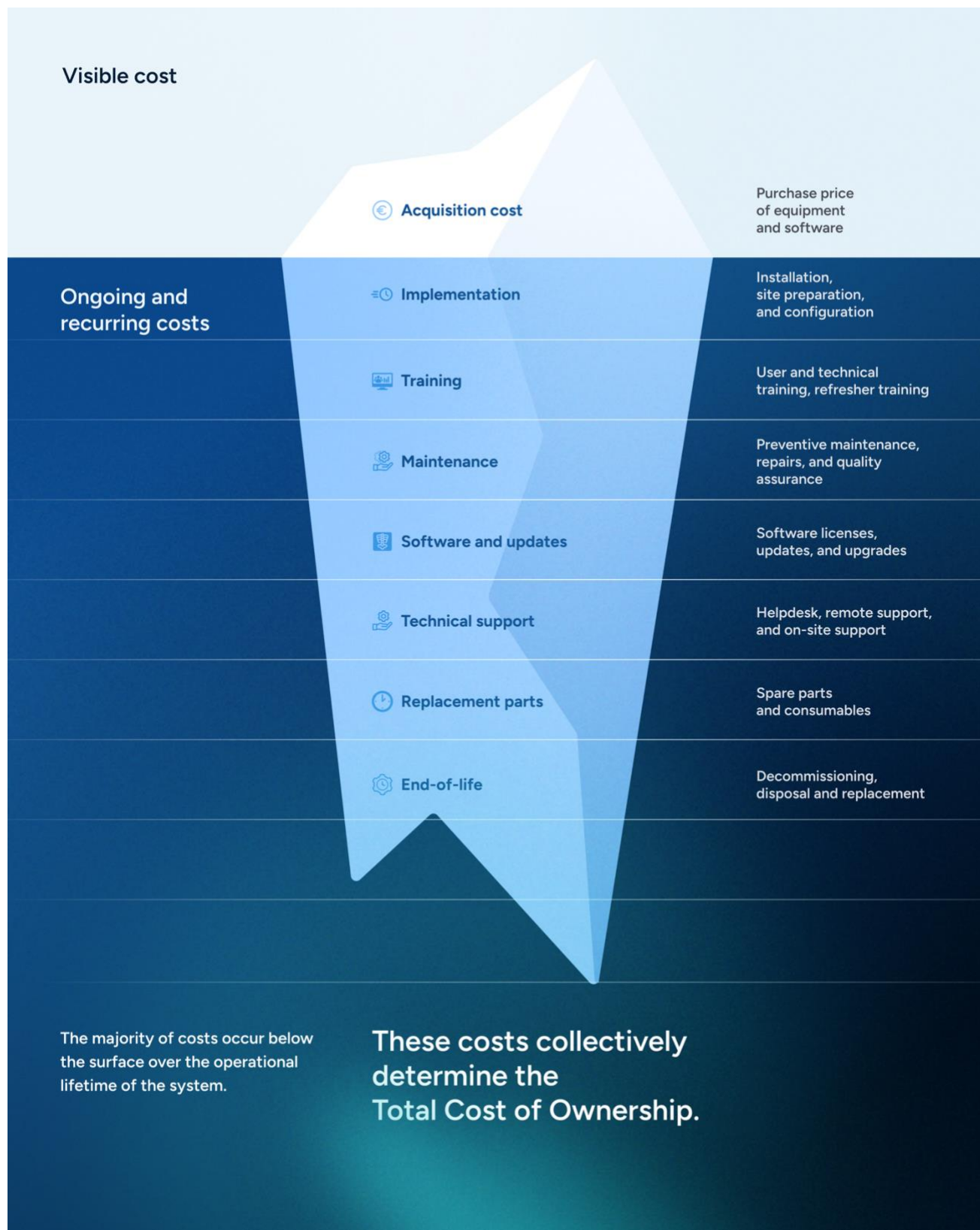


Figure 1. Acquisition cost is only part of the total cost of ownership. A lower acquisition cost should therefore not automatically be interpreted as a lower total cost of ownership, particularly where maintenance, replacement components, and other recurring costs are not included in the initial offering.

Building a predictable total cost of ownership

Key cost drivers of the total cost of ownership depend on the deployment model, program size, daily throughput, and local context; together they determine the resources required to implement, operate, and maintain a screening solution throughout its operational lifetime. But in general, they can be broken down into the following three categories: initial investment, operational and human resources, and maintenance and service costs.

Initial investment

The procurement and installation of a digital X-ray system or CAD software are initial investments in a screening program. These costs arrive early on, representing the most visible cost.

When planning, programs should consider the expected utilization of the system during its operational lifetime. Underutilized systems can result in higher per-screen costs, as fixed costs are spread across fewer screenings⁶. Estimating intended usage during program planning informs investment decisions and long-term budgeting.

It also helps programs anticipate future maintenance and replacement requirements, as expected utilization influences the replacement frequency of critical components over the equipment's operational lifetime, such as the batteries and X-ray tubes. For portable systems deployed in settings with unreliable or unavailable power infrastructure, battery performance can be particularly important to maintaining screening capacity and operational continuity.

By forecasting anticipated screening volumes during procurement, these recurring lifecycle costs can be incorporated into long-term budgets rather than treated as unexpected expenditure.

Infrastructure, installation, and site preparation requirements should also be considered as part of the initial investment. These requirements vary by deployment setting and can introduce additional operational costs. For instance, in locations with unreliable electricity, programs may need to budget for solar-powered battery packs. When deploying equipment, replacement parts or service engineers across multiple sites, this can increase transport and logistics costs.

The type of X-ray system selected also influences installation costs. Larger systems require more complex transport, site preparations, and installation, while portable systems can reduce transport and installation requirements for outreach activities. Selecting equipment that matches the intended use case can therefore help programs better estimate infrastructure and deployment costs during planning.

⁶ Bashir S, et al. Economic Analysis of Different Throughput Scenarios and Implementation Strategies of CAD Software. PLOS ONE. 2022.

Planning for predictable investments

Maintenance is a recurring component of the total cost of ownership. The challenge is therefore not whether maintenance will be required, but how programs choose to plan and budget for it.

Delft Imaging's warranty agreements are designed to support this approach by bringing together the services required to maintain equipment throughout its operational lifetime. Depending on the system and screening requirements, service agreements may include preventive and corrective maintenance, software updates, technical support, replacement work, refresher training and coverage of components and accessories, including batteries.

Warranty extensions can be procured alongside the system or during the initial warranty period, allowing programs to include these recurring costs within their implementation budget, guaranteeing a more predictable cost of ownership.

For instance, Delft Imaging works with programs to estimate expected equipment usage over the planned intervention period. This informs maintenance requirements and replacement of key wear components, such as the tube, the generator, or batteries. So, these cost items can be considered timely, before procurement decisions rather than after deployment. This improves cost predictability throughout the equipment lifecycle for more accurate budgeting.

Service and warranty agreements are tailored to the operational requirements of individual screening programs, considering the deployment model, local technical capacity, and long-term service needs.

While actual costs vary depending on system use and deployment location, even a single major component replacement can exceed the cost of an annual warranty extension agreement. Planning for maintenance through a service agreement therefore provides greater cost predictability compared to managing repairs on a per-case basis.

For portable X-ray systems, batteries provide a practical example of how equipment utilization can translate into lifecycle costs. Battery replacement requirements depend on screening volume, charging cycles, and operating conditions, making them an important consideration when estimating costs over the ownership period.

Planning input	Value	Result
Program duration	5 years	
Average X-ray examinations	200 per day	
Screening days	250 per year	250,000 examinations over 5 years
Generator battery lifespan	600 charging cycles	
Average exposures per charge	200	120,000 exposures per battery
Batteries supplied with system	2	240,000 exposures covered
Expected battery replacement		1 additional generator battery over 5 years
Estimated replacement cost (including transportation)		USD 5,718

Key takeaway

Under these assumptions, an additional generator battery would be expected over a five-year ownership period. When purchased separately, this represents an estimated replacement cost of approximately USD 5,718 (including transportation). By estimating screening volume during procurement and incorporating expected replacement requirements into a warranty agreement, programs can budget for these lifecycle costs upfront rather than face unexpected expenditure during implementation.

This approach is particularly valuable for components with finite operational lifetimes, where replacement frequency depends on utilization rather than age alone. By anticipating these replacement requirements during procurement, organizations can incorporate recurring lifecycle costs into program budgets from the outset.

Operational costs

Operating screening activities require ongoing investment in human resources throughout the lifetime of a program. Resources are needed to operate equipment, interpret results, provide technical support, and maintain continuity as personnel can change over time.

One of the most overlooked operational costs is staff turnover. As healthcare workers move between facilities or leave altogether, new personnel require onboarding and training, while existing users benefit from refresher training to maintain competencies, introduce software updates, and familiarize themselves with new functionality. Building local technical capacity further supports long-term efficiency by enabling operators to perform routine system checks and resolve minor technical issues independently, reducing unnecessary service requests and allowing specialized technical support to focus on more complex maintenance activities.

When planning the total cost of ownership, programs should therefore consider not only the personnel required to operate screening services, but also the resources needed to sustain workforce knowledge and technical capacity throughout the operational lifetime of the programs.

Supporting program continuity

Maintaining a skilled workforce extends beyond initial implementation. Staff turnover, evolving program requirements, and changing workflows can all increase training needs over time.

Together with refresher training, eLearning resources, and ongoing technical guidance, Delft Imaging helps organizations maintain operational continuity, support knowledge transfer, and reduce the risk of prolonged disruption throughout the equipment lifecycle.

Maintenance and service

Maintenance and service is among the highest recurring costs throughout the screening program. In addition to maintenance activities, programs should plan for the services required to keep equipment operational over time. These include technical support, software updates, replacement parts, logistics, and other activities that ensure continued operation of the system.

Maintenance and repair are a high recurring operational cost and are assessed as a proportion of the equipment acquisition value and can range between 5–10% of the initial equipment cost, depending on equipment type and maintenance approach.⁷

⁷ Miller R, et al. Linear accelerator maintenance cost analysis. *J Appl Clin Med Phys*. 2024.

Preventive and corrective maintenance

Maintenance generally consists of two complementary activities: preventive maintenance and corrective maintenance. Preventive maintenance is a planned activity carried out at scheduled intervals while equipment is functioning correctly. Routine inspections, functional checks, and other scheduled interventions help identify potential issues before they result in equipment failure, reducing downtime, extending equipment life, and lowering the likelihood of costly repairs.

Corrective maintenance is performed after a fault or system failure has occurred. In addition to repair costs, unexpected failures may require replacement parts, service visits, shipping, logistics, and other unplanned expenditures while screening activities are interrupted.

Although corrective maintenance cannot be avoided entirely, planning for preventive maintenance can reduce the frequency and severity of unexpected failures over the operational lifetime of the equipment. Considering both preventive and corrective maintenance during program planning helps organizations better anticipate maintenance costs, reduce financial uncertainty, and support a more predictable total cost of ownership.

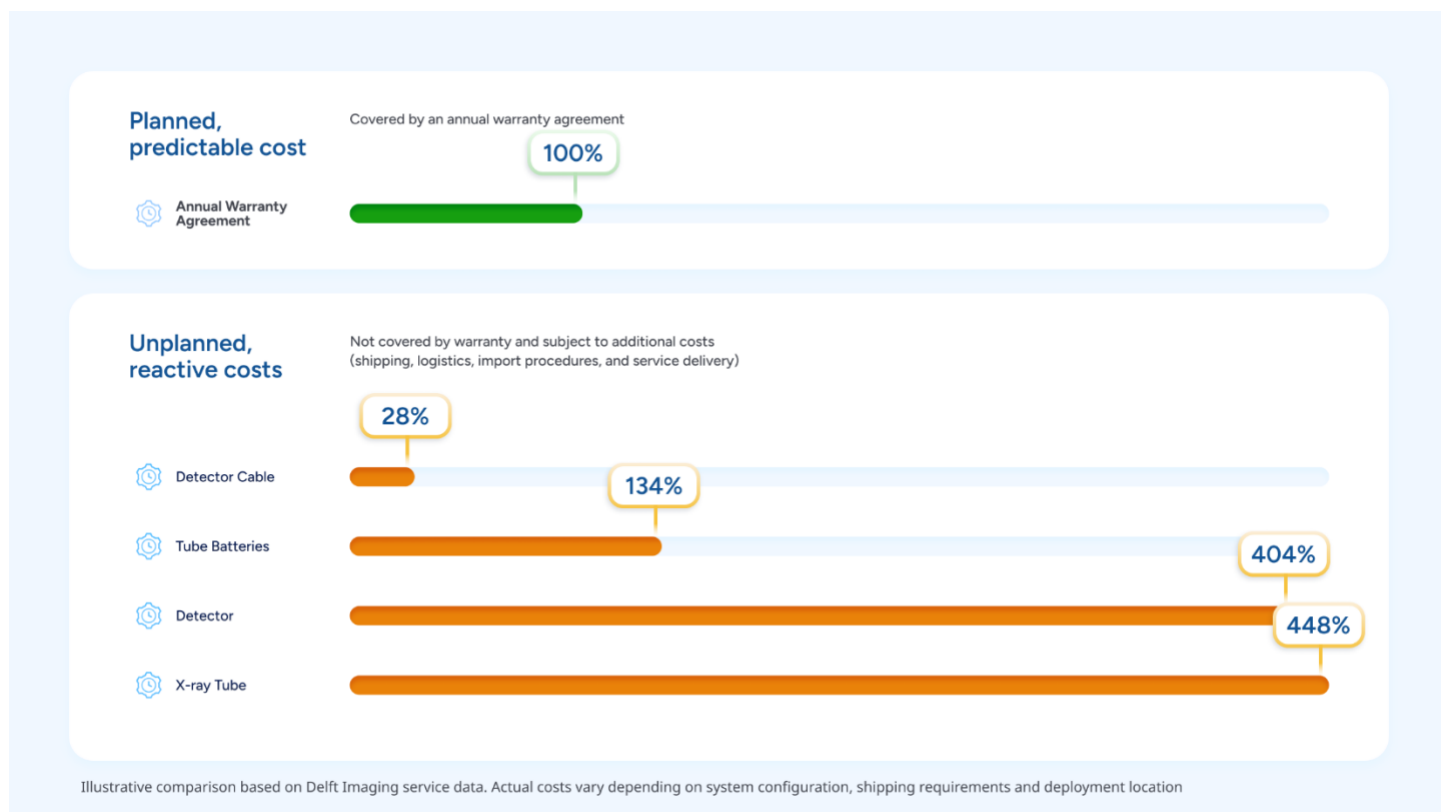
Warranty planning and replacement costs

When a component fails, the cost extends beyond the replacement part itself. Shipping, logistics, import procedures, and service delivery all contribute to the total cost of a repair. These costs are difficult to predict when maintenance is managed on an ad hoc basis, making it important to budget for maintenance from the outset. However, when warranty is still available, the cost for replacing broken parts as well as the cost associated with the logistics are covered under the warranty. Consequently, clients are not faced with unexpected, unpredictable high replacement costs.

Relative cost

Annual warranty agreement = 100%

*The following example is illustrative only. Actual replacement requirements vary depending on utilization patterns, operating conditions, and equipment configuration.



A single major component replacement (detector or X-ray tube) can cost more than **four times the value** of an annual warranty agreement.



Planning for maintenance through a service agreement helps transform unpredictable repair costs into a predictable budget.

Figure 2. Illustrative comparison of individual component replacement costs relative to a one-year warranty agreement based on Delft Imaging service data. Actual costs vary depending on system configuration, shipping requirements, and deployment location

The comparison shows why maintenance planning should be considered during procurement rather than after equipment deployment. While smaller component replacements may represent only a fraction of the annual warranty cost, a single major component failure, such as a detector or X-ray tube, can exceed the annual warranty agreement several times over. When managed individually, these repairs are also accompanied by shipping, logistics, service delivery, and administrative costs that further increase the total cost and commonly increase the fix time.

Including maintenance within the program budget through a planned service agreement helps remove this financial uncertainty by covering recurring maintenance activities and providing a more predictable approach to long-term ownership costs.

Downtime and service continuity

Equipment downtime is a consideration to be taken into account when discussing the total cost of ownership. Every period during which a system is unavailable reduces screening capacity, interrupts program activities, and delays access to diagnostic services. The duration and predictability of downtime depend largely on whether maintenance is planned or reactive.

Downtime associated with preventive maintenance can usually be scheduled around screening activities, minimizing disruption to service delivery. By contrast, corrective maintenance occurs only after equipment failure and is therefore less predictable. Before repairs can begin, facilities may need to complete procurement approvals, source replacement parts, arrange logistics, and, where applicable, complete import procedures. These delays can extend equipment outages, reduce utilization and disrupt program delivery.

Planning for preventive maintenance and long-term service support helps minimize unplanned downtime, maintain continuity of screening services, and improve budget predictability throughout the operational lifetime of the program. For TB programs, equipment downtime directly impacts case finding, treatment initiation, and public health outcomes.

Long-term service and support

Maintenance planning extends beyond repairs. Timely technical support, preventive maintenance and access to specialist expertise all contribute to preserving system availability and reducing operational disruption over the equipment lifetime.

Delft Imaging's warranty agreements are designed to support this approach by bringing together the services required to maintain equipment throughout its operational lifetime. Depending on the system and screening requirements, service agreements may include preventive and corrective maintenance, software updates, technical support, replacement work, refresher training and coverage of components and accessories.

Delft Imaging delivers these services through a structured support model combining local service partners, regional support offices, and a 24/7 helpdesk. These services are included within Delft Imaging's service and warranty agreements, enabling facilities to access support through a single service network while adapting the level of support to their operational requirements.

Delft Imaging's warranty model supports higher operational uptime by ensuring rapid replacement and support through local service providers and regional support networks that include decentralized spare parts stock locations.

This results in:

- Faster issue resolution
- Reduced interruption to screening activities
- Greater continuity of Active Case Finding programs
- Improved program reliability and results predictability
- Higher utilization rates of deployed X-ray systems

For donor-funded and government-led screening initiatives, continuity of service is essential to achieving TB program case notification targets and maximizing public health impact.

This support model is backed by measurable service commitments:

- Customer satisfaction: 4.9/5
- First response: <30 minutes
- Remote resolution: 99% within 24 hours

Conclusion

The purchase price represents only one component of the total cost of ownership. Over the lifetime of a screening program, recurring costs associated with operations, maintenance, service, infrastructure, and long-term support play an equally important role in determining the resources required to keep systems operational.

Understanding these cost drivers enables governments, donors, and implementing partners to move beyond short-term procurement decisions and plan for the full lifecycle of their investment. Incorporating maintenance, service, and operational support into program budgets from the outset helps reduce financial uncertainty, improve budget predictability and support the long-term continuity of screening services.

Extended warranty agreements provide the following key benefits:

- Reduced unforeseen replacement costs
- Lower maintenance budgeting uncertainty
- Fewer emergency procurement cycles
- Reduced logistics and shipping expenses
- Lower administrative overhead
- Increased screening productivity

A predictable total cost of ownership is not achieved by reducing costs alone, but by anticipating them. By considering the full lifecycle of a screening solution during procurement and selecting service arrangements that align with program requirements, programs can make better-informed investment decisions, reduce unexpected expenditure, and protect the long-term value of their investment.