



ConexBird Feature Description

For container handlers

V1.0 , August 2022

Principal Author: Nicholas Gallie



Contents

Introduction	3
Availability	3
Context	3
Solution	4
Benefit	5
Container Terminals	5
Operational	5
Environmental	7
Safety	7
Container Depots	8
Operational	8
Environmental	10
Safety	10
Durability	11
Context	11
Solution	12
Benefit	13
Container Terminals	14
Safety	14
Container Depots	14
Commercial	14
Safety	15
Conclusions	16



Introduction

ConexBird's spreader-mounted container measurement system offers the container shipping industry an entirely new way to think about and use its primary assets — containers. By providing tailored insight to supply-chain stakeholders each time a container is handled, many of the inefficiencies inherent to today's container logistics can be mitigated, or even eliminated entirely, through the application of ConexBird's novel technology. The purpose of this document is to illuminate to container handlers what such application would consist of within their facilities, and what the direct operational benefits would be from doing so.

Please note that this document will be continuously evolving as ConexBird's understanding of its benefits for container shipping grows. Furthermore, please note that this document is focused on the direct applications of ConexBird's system for container handlers (i.e. terminal and depot operators), with benefits for shipping lines and other stakeholders being covered in separate publications; consequently, any commercial benefits for container handlers arising from the sale of ConexBird insight to container owners have also been excluded, as they lie outside the scope of this report.

Availability

Context

Nominally, containers must be cleared for use before each cargo-bearing journey: this takes place at container depots, and is performed manually by dedicated container inspectors. Human container assessment is inherently prone to human error, thus introducing a great deal of subjectivity into the otherwise standardized, highly regular world of container logistics. This subjectivity invariably results in missed damages and inaccurate condition assessments, which can pose serious operational, commercial, liability and safety risks if left unresolved: container handlers are directly exposed to several of these risks, with current processes and technologies proving to be inadequate solutions.

The most obvious and immediate manifestation of these issues is through surplus container lifts/movements, which could have been prevented with timely and reliable knowledge on the availability status of each container. In addition to basic energy and equipment costs, the time and productivity lost through these surplus movements impair a terminal's capacity to quickly move containers from one vehicle to another — the key metric within which terminals compete against each other.

For depots, a growing labour gap means that skilled container inspectors are in dwindling supply, particularly in high-income markets — further exacerbating the supply-chain slowdowns caused by container M&R. There will likely always be a role for human container inspectors, particularly when concerning container repairs: however, all relevant stakeholders (including container inspectors themselves) agree that there is room to supplement and augment



inspectors' work with technology, which can automate much of the mundane work that is needed for container inspection and allow human judgment to be directed to the exception cases where it is needed most.

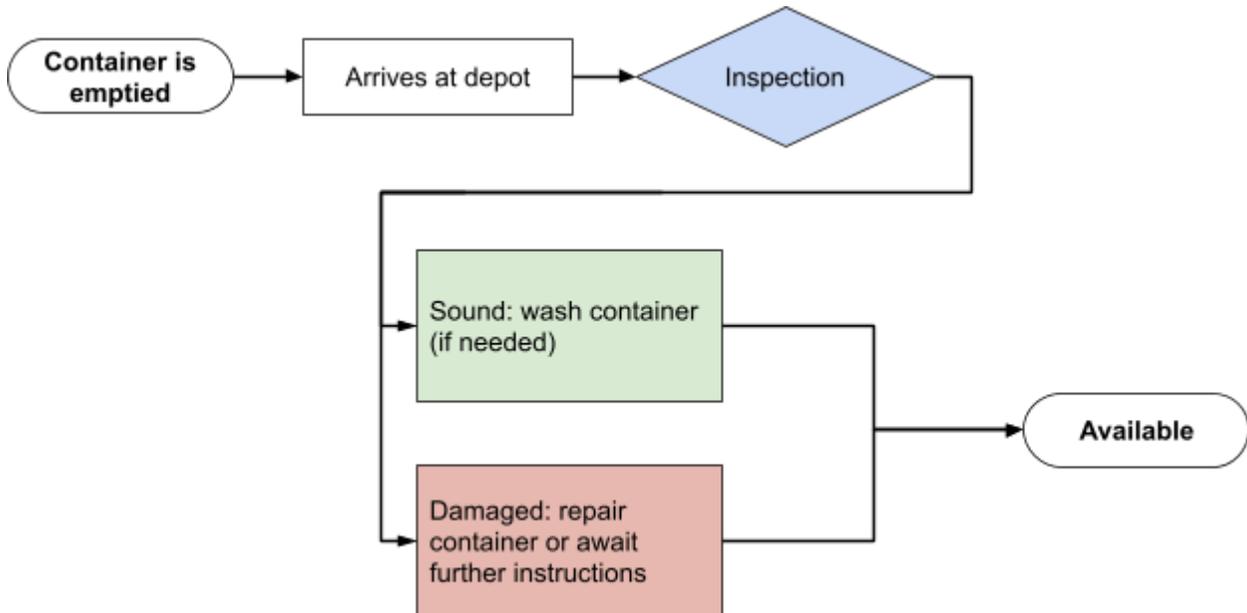


Figure 1: the current container inspection/M&R process.

Solution

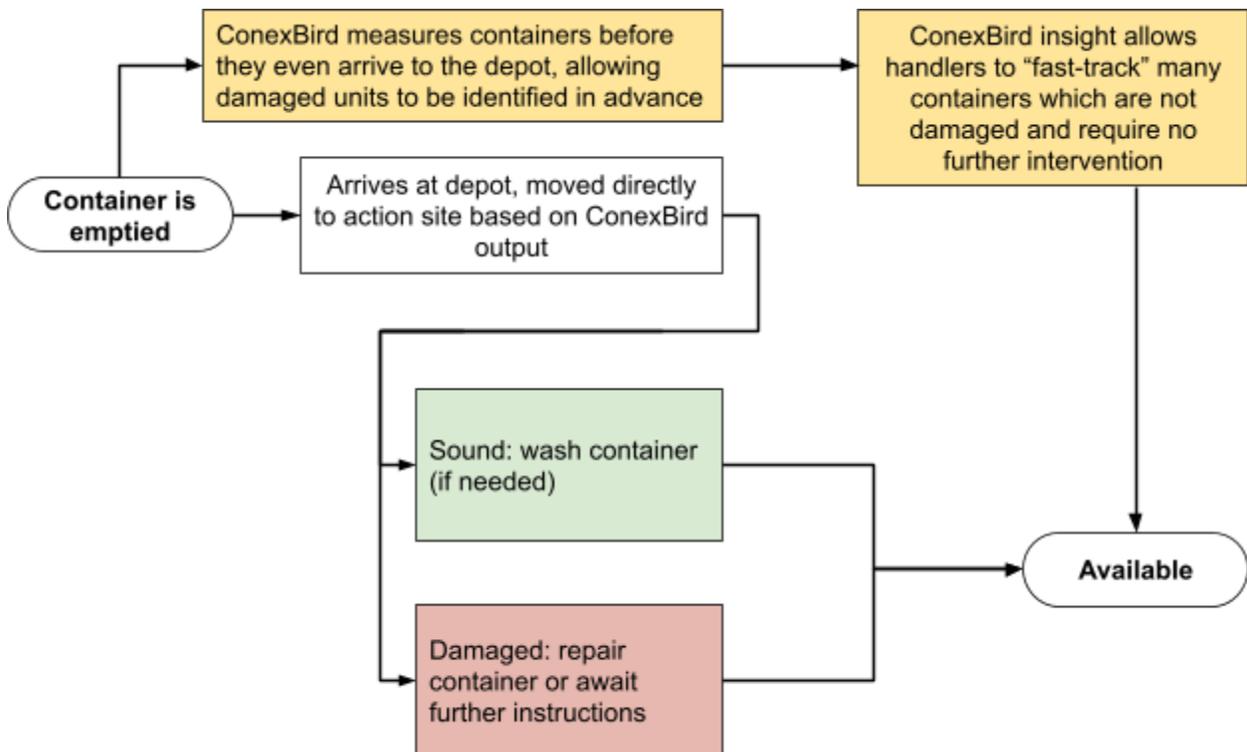


Figure 2: the enhanced container M&R process using ConexBird container information.



ConexBird's system can determine the presence or absence of damage on containers from container terminals, upon arrival via quay cranes. This allows decisions for many containers' allocation to be optimized based on their acceptability for carriers and shippers, particularly for units found to be damaged/unsuitable, which can be isolated from general circulation and treated accordingly. Not only can doing so directly reduce the number of "housekeeping" lifts performed by a facility (particularly a depot which has received ConexBird availability information in advance), but the improved acceptance of empty units provided to hauliers and cargo owners will further reduce the incidence of redundant container swaps (i.e. "callbacks — see below).

This solution would involve measuring each container's availability information from a terminal's quay cranes using ConexBird's system, and providing this information in real-time to the terminal via a TOS API or similar means. If the terminal and depot have agreed to coordinate their container handling on the basis of ConexBird's availability information (as suggested above), then further benefits from this information can be obtained by the depot and, by affiliation, the surrounding hinterland ecosystem: naturally, this is particularly the case for container terminals which offer their own depot/M&R services.

Benefit

Fundamentally, the advantage container handlers gain from ConexBird's availability information is prior knowledge of which containers are (or will be) deemed suitable for cargo transportation. Hence, improved routing and decisions can be made for containers on the basis of this information, such that surplus movements and conflicts with other stakeholders can be prevented.

Container Terminals

The estimates below have been made for a generic container terminal with an annual throughput of 1 million TEU: unless otherwise specified, all figures are assumed to be applicable on an annual basis. Please note that some key benefits, such as the reduction in safety risks due to improved damage insight, will be appropriately quantified once sufficient data becomes available: further insight into these use cases will emerge in subsequent versions of this report.

Operational

Container terminals stand to gain from having access to ConexBird's availability information as a means to reduce friction with associated downstream entities. Notably, a common issue faced by container terminals is the rejection of damaged outbound empty containers by road hauliers, who are unwilling to bear the potential liabilities resulting from unrecorded (but evidently present) container damages. Unfortunately, the presence of qualifying damages often does not occur until the unit in question has already been lifted from its stack and placed onto the truck:



at least two subsequent lifts¹ are thus needed to return the unit to an empty stack (for later processing/mediation) and to procure a replacement.

Terminal throughput (assumed)	1,000,000 TEU
TEU-box factor	0.6
Proportion of empty containers ²	20%
Proportion of damaged containers ³	20%
Proportion of undetected damages (assumed)	50%
Number of lifts per truck rejection incident	2
Total surplus lifts saved	≈ 25,000 lifts p.a.

Each of these surplus lifts has an associated financial cost.

Terminal throughput (assumed)	1,000,000 TEU
Surplus lifts saved	25,000
Operating cost per lift (assumed) ⁴	€50
Total surplus lift cost saved	≈ €1,200,000 p.a.

Furthermore, these rejection incidents can also become a substantial source of congestion around a terminal’s truck gates. This is due to the growing backlog of trucks which must wait for the rejection(s) to be resolved in order for them to enter the terminal, as well as the fact that empty container handovers (and hence rejections) themselves are often performed in the vicinity of the truck gates. Hence, a considerable amount of “operating time” for truck gates and related equipment can be saved through the application of ConexBird’s availability information, potentially allowing for increased container traffic through the terminal (and thus increased productivity/revenue).

¹ Note: empty lifts in container terminals are frequently performed by empty container handlers (i.e. “side-loaders”), which are capable of simultaneous horizontal and vertical container transportation — such will be the assumption in this document for empty container lifts in container terminals and depots.

² “6.3 – Port Terminals” in *The Geography of Transport Systems*. Jean-Paul Rodrigue and Theo Notteboom, 2020.

³ “Minimizing cost of empty container repositioning in port hinterlands, while taking repair operations into account”. T. Hjortnaes et al., 2017.
https://www.researchgate.net/publication/311962075_Minimizing_cost_of_empty_container_repositioning_in_port_hinterlands_while_taking_repair_operations_into_account

⁴ Assumed, based on a combination of expert opinion and external sources, e.g.: “Improving marine container terminal productivity”. The Tioga Group, 2010.
http://tiogagroup.com/docs/Tioga_CHCP_Productivity_Report.pdf



Terminal throughput (assumed)	1,000,000 TEU
Surplus lifts saved	25,000
Total rejection incidents	12,000
Operating time lost per incident (assumed)	10 minutes
Total operating time saved	≈ 2,000 hours p.a.

Environmental

The surplus lifts described above also incur an environmental cost on the terminal’s behalf: these emissions could thus be prevented through the application of ConexBird’s availability information as described above.

Terminal throughput (assumed)	1,000,000 TEU
Surplus lifts saved	25,000
CO ₂ emissions per lift (assumed)	5 Kg
Total surplus lift emissions saved	≈ 130,000 Kg CO₂ p.a.

Further (although less readily quantifiable) reductions are to be obtained through reduced truck engine idling, reduced empty-handler engine idling and other corollary benefits resulting from the application of ConexBird’s availability insight.

Safety

The detection of otherwise unseen container damages through ConexBird’s availability information implies the detection of unseen dangerous damages, which pose operational safety and liability risks to container handlers and related parties; furthermore, the use of ConexBird’s system can also be extended to specifically alert operators once one of these dangerous, critically-damaged containers has been detected.

Notably, damages to container corner casts and understructures often go unnoticed due to the practical challenges of observing/surveying these components, even though they can grow to pose serious safety hazards. ConexBird’s measurement technique is uniquely well-suited to detecting cracks, dents and other causes of critical failure in these components, helping prevent imminent structural failures as well as providing container owners with foresight into risk sources as they emerge.



Container Depots

As with terminals, container depots can also gain efficiency improvements through the optimizations afforded by ConexBird's availability information. The extent to which container moves can be reduced with availability foresight varies according to each depot's processes, so some simplifying assumptions must be made about the "generic" depot with a 100,000 TEU annual throughput to be used for the calculations below:

- The depot has separate surveying (inspection), damage and washing stations for containers, so containers must be moved between them as they undergo the M&R process (of inspection, repair and cleaning).
 - For each of these steps, there are often "backlog" stacks which, if container flow exceeds capacity, hold excess containers waiting to complete the step in question: if the stack is used, an extra lift will be incurred between each step in the M&R process. Given the inherent uncertainty involved in whether or not such capacity backlogs will exist, these "backlog lifts" are excluded from the calculations made in this document.
- All containers entering the depot are subjected to the M&R process: if damaged, they will be repaired on-site, and containers will also be cleaned at the on-site washing stations if needed.
- All container movements within the depot will be performed by empty container handlers, meaning that each container movement is counted as a single lift.
- The depot has received ConexBird information in advance, from an upstream terminal through which inbound containers have recently passed. This allows decisions for each container's routing/placement to be made ahead of time, as opposed to when the container has already arrived at the depot (which, given the depot's existing container-inspection apparatus, would make ConexBird information supplementary at best and unable to truly transform depot operations).

It is widely understood within container logistics that the above assumptions do not all apply to many real-world container depots, meaning that the following estimations must be taken as general predictions rather than specific forecasts.

Operational

Containers are typically inspected for damages and cleanliness upon arrival at a depot: with ConexBird's availability information, many undamaged units can be "pre-cleared" as not requiring any substantial M&R work beyond possible cleaning, and thus be taken directly to the washing stations. In this manner, one lift (from the surveying area to the washing station) can be saved per container.



Depot throughput (assumed)	100,000 TEU
TEU-box factor	0.6
Proportion of containers which could be accelerated by ConexBird due to their “available” status (assumed) ⁵	50%
Lifts saved for available containers	≈ 30,000 lifts p.a.

Furthermore, the majority of the containers which ConexBird assesses to be unavailable (and therefore damaged) can also be rerouted directly towards the repair yard, as they are already known to be in need of repair even before the exact nature of the damage is known.

Depot throughput (assumed)	100,000 TEU
TEU-box factor	0.6
Proportion of containers which are damaged ³	20%
Proportion of damaged containers which ConexBird can accelerate (assumed)	80%
Lifts saved for unavailable containers	≈ 10,000 lifts p.a.

The total costs and time/productivity saved through these lifts is estimated below:

Depot throughput (assumed)	100,000 TEU
Lifts saved for available containers	≈ 30,000 lifts p.a.
Lifts saved for unavailable containers	≈ 10,000 lifts p.a.
Total surplus lifts saved	≈ 40,000 lifts p.a.
Cost per lift (assumed) ⁶	€30
Total surplus lift costs saved	≈ €1,200,000 p.a.
Operating time per lift (estimated)	2 minutes
Total surplus lift time saved	≈ 1,300 hours p.a.

⁵ This is a conservative estimate, as ConexBird expects to be able to provide decisive structural clearance for the vast majority of the ~80% of containers which are not damaged (at any given moment).

⁶ Note: the per-lift operating cost has been assumed to be lower for a depot than for a terminal, as there are likely shorter horizontal transport distances involved.



In addition to the time saved from reducing surplus container movements, depots can also use ConexBird availability information to reduce the time spent by container inspectors on unnecessary inspections of healthy containers, thus allowing the attention of these key personnel to be focused on damaged containers and exception handling. Some of the time thus saved would be offset by the additional time spent on more thorough inspections of unavailable and fragile units: however, this “inspector time” will become far more productive for the depot, as it will uncover proportionally more damages (and thus sources of M&R revenue).

Depot throughput (assumed)	100,000 TEU
TEU-box factor	0.6
Proportion of containers which could be accelerated by ConexBird due to their “available” status (assumed)	50%
Time spent per container inspection (assumed)	10 minutes
Time saved on container inspections	≈ 5,000 hours p.a.

Environmental

The lifts saved by a depot through the application of ConexBird’s availability information also results in a reduction in CO₂ emissions.

Depot throughput (assumed)	100,000 TEU
Surplus lifts saved	40,000
CO ₂ emissions per lift (assumed)	3 Kg
Total surplus lift emissions saved	≈ 120,000 Kg CO₂ p.a.

As with terminals, further reductions in the depot’s environmental footprint are expected from the optimization made possible by ConexBird.

Safety

The safety benefit of systematically knowing which containers are unavailable (and likely damaged) is, in essence, the same for depots as it is for terminals. For depots in particular, this knowledge notably decreases safety risks for container inspectors and other yard workers, who are now able to know in advance which containers pose elevated risks for movement and interaction (e.g. entry inside the container).



Durability

Context

Containers naturally lose their strength and robustness over time and with use: in technical terms, this is due to the container steel's *material fatigue* — the accumulation of microscopic cracks, tears and other imperfections which collectively reduce the container's integrity and durability. These deficiencies can and will compound into larger, more serious faults with increasing frequency as the container ages, meaning that a container will eventually cost its owner more in repairs, liabilities and downtime than it makes back in revenue-generating cargo transportation.

Container owners are well aware of container degradation and the problems it leads to, so they currently mitigate it by depreciating their assets over a fixed period, with the *de facto* standard for dry boxes currently being 12 years: after this point, containers are sold to traders in the sizeable secondary market for “non cargo-worthy” containers, or simply scrapped (note: when container demand exceeds supply, the normal cut-off dates are often ignored and older, weaker containers are retained or even reintroduced into service).

The use of age as a proxy for container durability is a simple method which nonetheless does reduce durability-related issues to a certain extent, since a container's durability is invariably linked with its age: however, it is also linked to the container's individual usage patterns and history of incidents (damages, drops, etc.), which can vary substantially between containers. Consequently, container fleet managers and depot inspectors both agree that many units should have been decommissioned well before their “official” retirement age, whereas many more could be kept safely and productively in service for several years beyond it; until now, however, the assessment of a given container's material fatigue (beyond what can be surmised from its age) has been a fruitless, subjective and therefore largely abandoned endeavor to date.

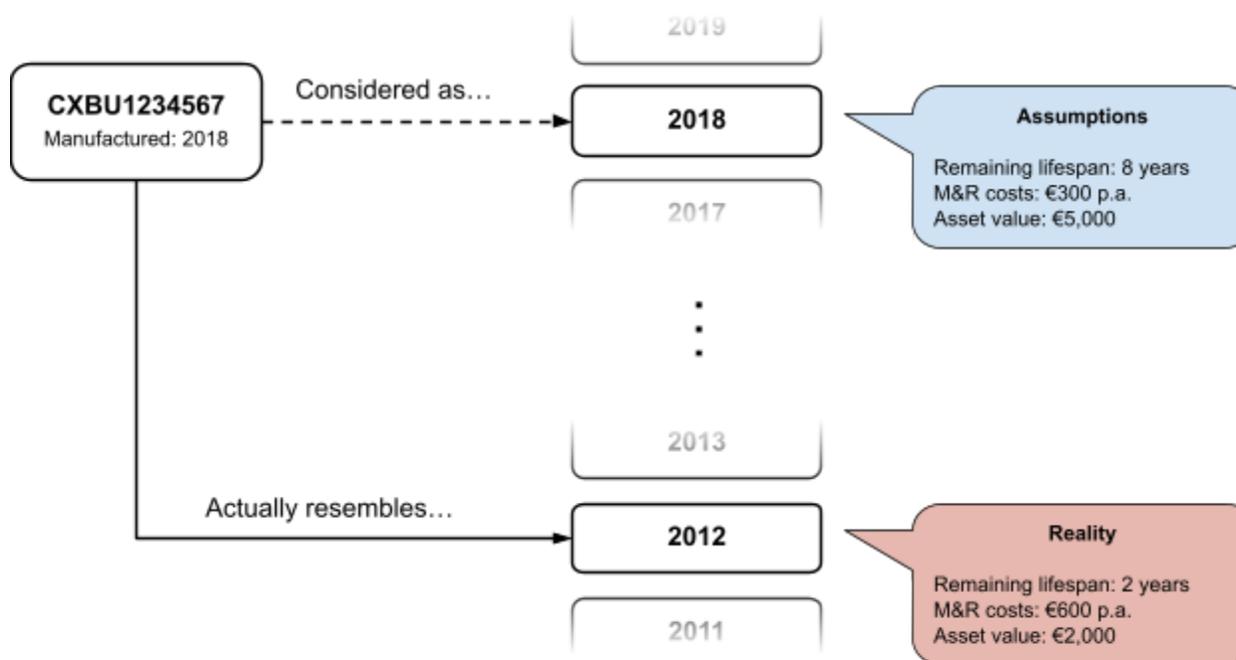


Figure 3: the current knowledge gap for container durability. Note that the container in question, although manufactured in 2018, is significantly weaker and less durable than would be expected from a container manufactured in 2018 at the time of measurement.

Solution

ConexBird’s durability information eliminates uncertainty and subjectivity from container durability assessment, and is thus set to revolutionize container fleet management for owners and M&R providers alike. Resonance testing will reveal the true material condition of each container to a far more objective and reliable degree than other methods; each container measured by ConexBird’s system is compared to our global measurement database, from which valuable comparative insight can be derived.

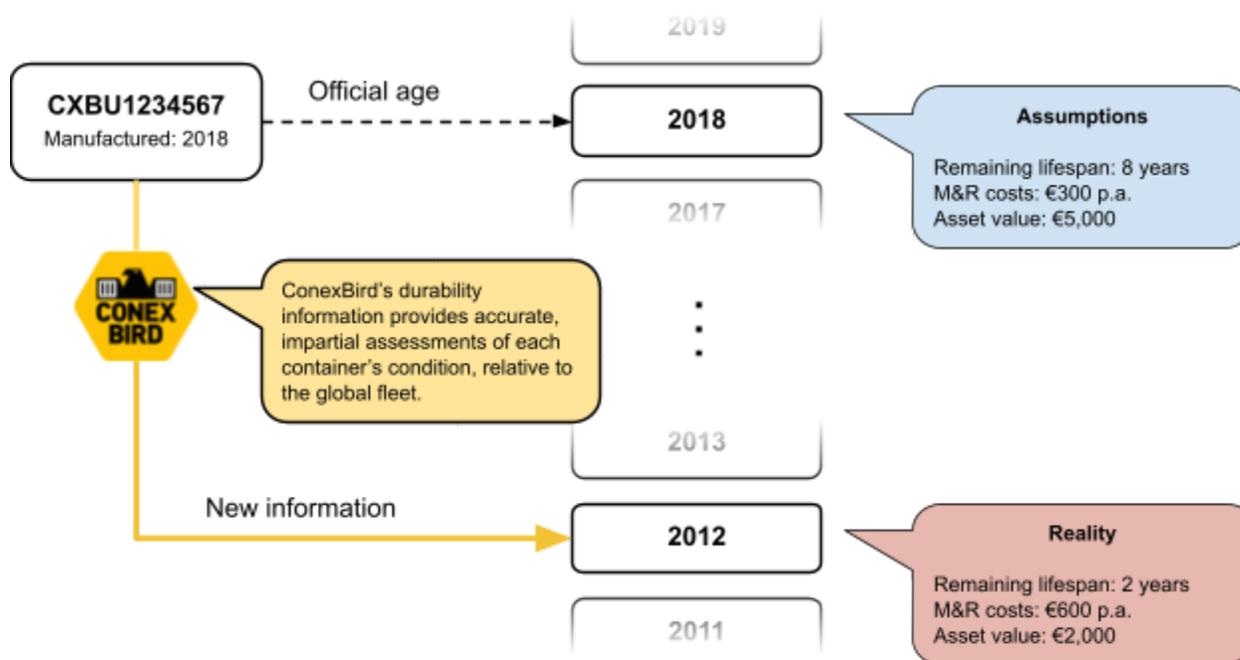


Figure 4: ConexBird's solution for durability-conscious container fleet management.

As an example, a container which was manufactured in 2018 (i.e. four years old, at the time of measurement) may have undergone multiple collisions and periods with rough conditions: as a result, its durability has been reduced to the point where ConexBird determines that the container more closely resembles a typical container made in 2012 (i.e. ten years old) — a six-year difference equivalent to half the container's nominal lifespan. This container will break down more frequently and severely than expected, and may soon become more of a liability than an asset: furthermore, should it be kept in service for its full nominal lifespan, the container's end-of-life resale value will likely be far lower than expected (and may even become negative).

When mounted on quay cranes at container terminals, ConexBird's system is able to provide large quantities of detailed, accurate durability information to entire hinterland ecosystems, including both nearby depots and the owners/users of the containers in question.



Benefit

Container Terminals

Much of the benefit ConexBird's durability insight offers to container terminals is indirect, by offering terminals a new revenue stream through selling this insight to their shipping-line customers. However, it is also important to observe how durability information can be directly used by terminal operators to improve yard safety.

Safety

ConexBird durability information can alert terminal operators to the arrival of critically-weak, dangerous containers which must be handled and treated with care to prevent serious incidents such as container drops and stack collapses. By itself, container weakness is rarely a direct cause of stack collapses (or, for that matter, other serious yard safety incidents), but it is often an aggravating factor⁷, as fragile containers may not be able to handle the same stresses as healthy, durable boxes.

The effect of container fragility on yard safety is also growing, as industry trends (larger ships/cranes, faster movements) mean that containers are being subjected to progressively larger G-forces which they may not have been designed for. In response to the same pressures, crane and spreader manufacturers have been redesigning their equipment in recent years to handle the increased acceleration: containers, on the other hand, have actually been getting *weaker* overall, due to a trifecta of extended lifespans, heavier cargoes and design tweaks.

The open question of durability further compounds the issue of whether today's containers can handle tomorrow's demands, meaning that ConexBird's accurate appraisals of each unit's structural integrity offer new opportunities for container terminals and related stakeholders to assess and improve the safety of their operations.

⁷ "Container stack collapses: causes and solutions". Standard Club, 2021.
<https://www.standard-club.com/knowledge-news/article-container-stack-collapses-causes-and-solutions-1615/>



Container Depots

Depots will be able to utilize ConexBird’s durability information to increase the detection of specific, repairable damages by their container inspectors, thus increasing the overall volume of M&R work (and revenue) available.

Commercial

The presence of undetected structural weakness within container fleets strongly implies the presence of undetected damages as well: hence, depots possessing ConexBird durability information for inbound units will have a wider array of container damages from which to generate repair revenue. In particular, units which are fragile and weaker than expected are highly likely to be in need of M&R work, meaning that thorough manual inspection of these specific units will yield high returns for depots able to distinguish them from the overall container fleet (through ConexBird).

Depot throughput (assumed)	100,000 TEU
Proportion of damages resulting from weak containers (assumed) ⁸	30%
Proportion of undetected damages (assumed)	50%
Proportion of weak containers kept in service by owner (assumed) ⁹	70%
Average repair cost per damaged TEU ³	€120
Extra revenue from durability insight	≈ €1,300,000 p.a.

Safety

In general, the safety applications of ConexBird’s durability information for container terminals are also applicable to depots, for which the high reliance on personnel in open yard areas (container inspectors, M&R technicians) creates a strong imperative to make use of such information to reduce on-site risks and liabilities.

⁸ Based on the following: (10% prevalence of weak containers – assumed) × (60% likelihood of a fragile container being damaged per trip – assumed) ÷ (20% prevalence of container damages per trip (from ³ — Hjortnaes et al., 2017))

⁹ Note: the very same durability information provided to depots, when providing to shipping lines and other container owners, will allow these owners to selectively remove the worst-performing units from circulation, thus reducing the amount of durability-related M&R work available.



Conclusions

The sum of the benefits ConexBird can provide for a container terminal with a 1,000,000 TEU throughput are summarized below:

Total surplus lifts saved	≈ 25,000 lifts p.a.
Total surplus lift cost saved	≈ €1,200,000 p.a.
Total operating time saved	≈ 2,000 hours p.a.
Total surplus lift emissions saved	≈ 130,000 Kg CO₂ p.a.

By working with a terminal which has ConexBird’s system installed on its quay cranes, a container depot with a 100,000 TEU throughput is similarly able to obtain the following benefits (including a total financial windfall of €2,500,000 p.a.):

Total surplus lifts saved	≈ 40,000 lifts p.a.
Total surplus lift costs saved	≈ €1,200,000 p.a.
Total surplus lift time saved	≈ 1,300 hours p.a.
Time saved on container inspections	≈ 5,000 hours p.a.
Total surplus lift emissions saved	≈ 120,000 Kg CO₂ p.a.
Extra revenue from durability insight	≈ €1,300,000 p.a.

It naturally follows that a container terminal with proprietary in-house or affiliated depot operations will be able to capture both benefit streams, along with further potential synergies arising from ConexBird’s insight into container conditions. Regardless, the amounts visible above present compelling cases for terminals and depots to incorporate Conexbird into their workflows. Furthermore, the substantial benefits ConexBird can offer to other container stakeholders (in particular, to the terminals’ and depots’ shipping-line customers) strongly implies that these parties will be seeking adoption of ConexBird technology at container handling facilities, meaning that early adopters (amongst terminals and depots) of ConexBird can gain a competitive edge by offering added-value services and thus generate a true “win-win” situation for the containerized supply chain as a whole.

The information in this document covers only a fraction of the full scope of applications for ConexBird’s system, many of which we are still researching the full potential of: given the versatility and precision of our system, we are certain that there are also further use cases that have yet to be discovered. Hence, we believe that, if anything, what is presented here is an underestimate of the true potential our solution can bring to container shipping. By working



together with container terminals, container depots and other stakeholders, we can collectively ensure that container shipping has the condition insight it needs and the bright future it deserves.