360Platform
Supply Chain Management Software

CarbonOne

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From Product Visibility to Product Carbon Intelligence to Product Intelligence

Lessons Learned from a Titanium Fan Disk Supply Chain Analysis

Executive Summary

Manufacturers are entering a new industrial era where carbon emissions, supply chain resilience, regulatory compliance, and sourcing decisions are becoming increasingly interconnected.

Product Carbon Footprints (PCFs) are rapidly evolving from sustainability reporting tools into operational and strategic decision-making instruments. However, many existing carbon models still rely heavily on secondary datasets, generalized assumptions, and limited visibility into the actual structure of supply chains.

Using a Titanium Fan Disk aerospace case study, CarbonOne and 360platform demonstrate how detailed product intelligence — including suppliers, facilities, countries of origin, transportation pathways, and transformation stages — can materially improve carbon modeling and reveal operational insights that traditional approaches often fail to capture.

The broader implication is increasingly clear: carbon accounting without product-level supply chain intelligence will remain structurally limited.

Key Findings

Equivalent products can have materially different carbon footprints

Two sourcing scenarios produced functionally identical Titanium Fan Disks with an 11% difference in Product Carbon Footprint.

Kroll reduction dominates emissions

The titanium sponge production process accounted for approximately 53–60% of total product emissions.

Transformation losses amplify hidden carbon

Producing a 40 kg Titanium Fan Disk required 336 kg of upstream material and 608 kg of mined ore.

Transportation mattered less than expected

A sourcing pathway with over three times higher transportation emissions still generated the lower overall footprint.

Product visibility improves carbon intelligence

Supplier, facility, country, and transportation data revealed emissions drivers that conventional carbon accounting often misses.

Carbon is becoming a decision variable

Product Carbon Footprints can support sourcing, procurement, compliance, and operational decision-making.

Product Visibility is becoming the foundation of Product Intelligence

The next generation of industrial decision-making will increasingly connect carbon, supply chain, risk, and regulatory intelligence at the product level.

Product Visibility is the foundation of Product Carbon Intelligence.

1. The New Manufacturing Reality

Manufacturers are increasingly being asked to quantify emissions, evaluate supplier pathways, assess geopolitical exposure, and prepare for emerging regulatory frameworks such as:

- ⇒ EU Carbon Border Adjustment Mechanism (CBAM)
- ⇒ Scope 3 reporting requirements
- ⇒ Digital Product Passports (DPPs)
- ⇒ Corporate sustainability disclosure frameworks

At the same time, organizations face growing operational instability including trade restrictions, transportation disruptions, sanctions, and supplier concentration risks.

2. The Structural Limitation of Traditional PCFs

Most Product Carbon Footprints still rely heavily on industry averages, generalized lifecycle datasets, and simplified assumptions.

While useful for high-level estimations, these approaches become increasingly limited when applied to complex manufactured products involving:

- ⇒ Multiple supplier tiers
- ⇒ Significant transformation stages
- ⇒ Geographically fragmented sourcing
- ⇒ Industrial energy intensity differences
- ⇒ Material conversion losses

Without product-level intelligence, important emissions drivers often remain invisible.

3. Titanium Fan Disk Case Study

The Titanium Fan Disk was selected because it represents a highly complex aerospace component involving multiple transformation stages, energy-intensive metallurgy, significant material losses, and globally distributed sourcing.

The analyzed product was a forged Ti-6Al-4V Titanium Fan Disk with an approximate finished weight of 40 kg.

4. Understanding Buy-to-Fly Ratios

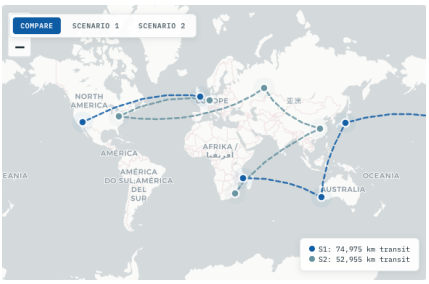
One of the most important findings of the analysis was the impact of buy-to-fly ratios on embedded carbon emissions.

Buy-to-fly ratio describes the quantity of input material required to produce one unit of finished aerospace component.

For titanium aerospace components, large quantities of material are removed during forging and machining processes. The analysis demonstrated that transformation losses materially amplify upstream emissions throughout the supply chain.

5. Building Product-Level Visibility

360platform developed a detailed digital representation of the Titanium Fan Disk supply chain including:



- ⇒ Product structure
- ⇒ Input & Raw materials
- ⇒ Supplier tiers
- ⇒ Facilities
- ⇒ Countries of origin
- ⇒ Transportation pathways
- ⇒ Transformation stages

Representative suppliers included ore suppliers in Mozambique and South Africa, titanium sponge producers in Japan and Kazakhstan, billet suppliers in the United States and China, and forging facilities in Germany and the United Kingdom.

6. From Visibility to Carbon Intelligence

CarbonOne used the product intelligence layer to construct a detailed Product Carbon Footprint model integrating:

⇒ Supplier pathways
⇒ Country-specific emission factors
⇒ Transportation distances
⇒ Transformation stages
⇒ Material conversion losses
⇒ Buy-to-fly assumptions

Rather than producing a purely static footprint, the analysis revealed how operational and sourcing decisions directly influence carbon outcomes.

7. Scenario Comparison

Two representative sourcing pathways were modeled to evaluate how supplier selection, geography, industrial energy mixes, and transformation efficiencies influence final product emissions.

Variable	Configuration 1	Configuration 2
Tier 1 Supplier	Doncasters (UK)	Otto Fuchs (Germany)
Ore Extraction	Mozambique	South Africa
Titanium Sponge Source	Japan	Kazakhstan
Billet Supplier	ATI Specialty Materials (USA)	Western Superconducting (China)
Transport Profile	Lower	Higher
Total PCF	13,971 $kgCO_2e$/disk	12,402 $kgCO_2e$/disk
Carbon Intensity	349 $kgCO_2e$/kg	310 $kgCO_2e$/kg

Equivalent products can have materially different carbon footprints

8. Quantified Findings

Although both sourcing scenarios produced functionally identical aerospace-grade Titanium Fan Disks, the resulting Product Carbon Footprints differed by approximately 11%.

⇒ Scenario 1 (Doncasters UK): 13,971 $kgCO_2e$/disk

⇒ Scenario 2 (Otto Fuchs Germany): 12,402 $kgCO_2e$/disk

This represents a difference of approximately 1,568 $kgCO_2e$ per finished disk.

The variation was primarily driven by differences in upstream titanium processing pathways and industrial energy intensity.

Kroll reduction dominates the product footprint

The magnesium-driven Kroll reduction stage represented approximately 53–60% of the total Product Carbon Footprint across both scenarios.

⇒ Scenario 1: ~8,357 $kgCO_2e$

⇒ Scenario 2: ~6,500 $kgCO_2e$

The analysis demonstrated that upstream titanium reduction processes dominate the emissions profile far more than downstream machining or transportation.

Transformation losses amplify hidden carbon

The analysis confirmed the major influence of buy-to-fly ratios on embedded emissions.

The 40 kg finished Titanium Fan Disk originated from approximately:

⇒ 336 kg of upstream input material

⇒ 608 kg of mined ore

Approximately 87.5% of the material mass was removed during industrial transformation stages.

As a result, a substantial portion of total emissions became associated with material that ultimately became scrap.

Transportation mattered less than expected

Configuration 2 generated approximately 3.3 times more transportation emissions than Configuration 1.

⇒ Configuration 1 transport emissions: 252 $kgCO_2e$

⇒ Configuration 2 transport emissions: 823 $kgCO_2e$

However, despite significantly higher freight emissions, Configuration 2 still produced the lower overall Product Carbon Footprint.

This finding suggests that upstream industrial processing intensity can outweigh transportation-related emissions in complex metallurgical supply chains.

Minor alloying elements can carry disproportionate carbon intensity

Vanadium represented only approximately 4% of total disk mass but exhibited extremely high carbon intensity.

⇒ Aluminium: ~8.21 $kgCO_2e/kg$

⇒ Vanadium: ~129.9 $kgCO_2e/kg$

This demonstrates that relatively small alloying inputs may carry disproportionate carbon impacts and should not be ignored within Product Carbon Footprint modeling.

9. Beyond Carbon Accounting

The same product intelligence foundation used for Product Carbon Footprint modeling can support a broader set of operational and regulatory objectives including:

⇒ Supply chain risk management

⇒ Digital Product Passports

⇒ CBAM readiness

⇒ Supplier resilience analysis

⇒ Strategic sourcing

⇒ Geopolitical exposure analysis

This illustrates the emergence of Product Intelligence Platforms capable of integrating operational, environmental, regulatory, and carbon intelligence into a unified decision-support layer.

Product Visibility
⬇
Product Carbon Intelligence
⬇
Product-Level Decision Intelligence
⬇
Product Intelligence Platforms

The Titanium Fan Disk case study demonstrates that Product Carbon Intelligence fundamentally depends on Product Visibility.

As carbon increasingly becomes an operational decision variable rather than simply a reporting metric, manufacturers will require integrated Product Intelligence Platforms capable of combining:

- ⇒ Supply chain intelligence
- ⇒ Carbon intelligence
- ⇒ Regulatory intelligence
- ⇒ Risk intelligence
- ⇒ Supplier intelligence

The Titanium Fan Disk case study is not merely a carbon exercise. It demonstrates the emergence of a new category of Product Intelligence Platforms.

The broader implication is increasingly clear: Product Visibility is becoming the foundation of the next generation of industrial decision-making.

About CarbonOne

CarbonOne is a Canadian carbon intelligence company founded to make carbon measurement simple, affordable, and credible for the companies that need it most.

Built by experts with decades of experience across the consumer-packaged goods sector, CarbonOne helps organizations measure, report, and reduce product-level carbon emissions through practical and decision-oriented lifecycle analysis.

CarbonOne enables companies to transform carbon from a reporting requirement into a strategic operational variable.

CarbonOne

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About 360platform

360platform is a Canadian Product Intelligence Platform that helps manufacturers build detailed visibility into products and multi-tier supply chains.

The platform combines supply chain visibility, supplier intelligence, regulatory intelligence, and risk intelligence to support Product Carbon Footprints (PCFs), Digital Product Passports (DPPs), CBAM readiness, supplier resilience, and strategic sourcing initiatives.

360platform helps organizations transform product and supply chain data into actionable operational intelligence.

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