Caterpillar Sustainability Challenges and the Physical Internet

IPIC 2016

3RD INTERNATIONAL PHYSICAL INTERNET CONFERENCE

Agenda

- Caterpillar overview
- Engineered Value Chain (EVC) program
- Physical Internet tie-in: sustainability and profitability
  - Plan For Every Part (PFEP)
  - Internet of Things (IOT)
  - Regional Sourcing
  - Across the Table
  - 3D printing
- Summary

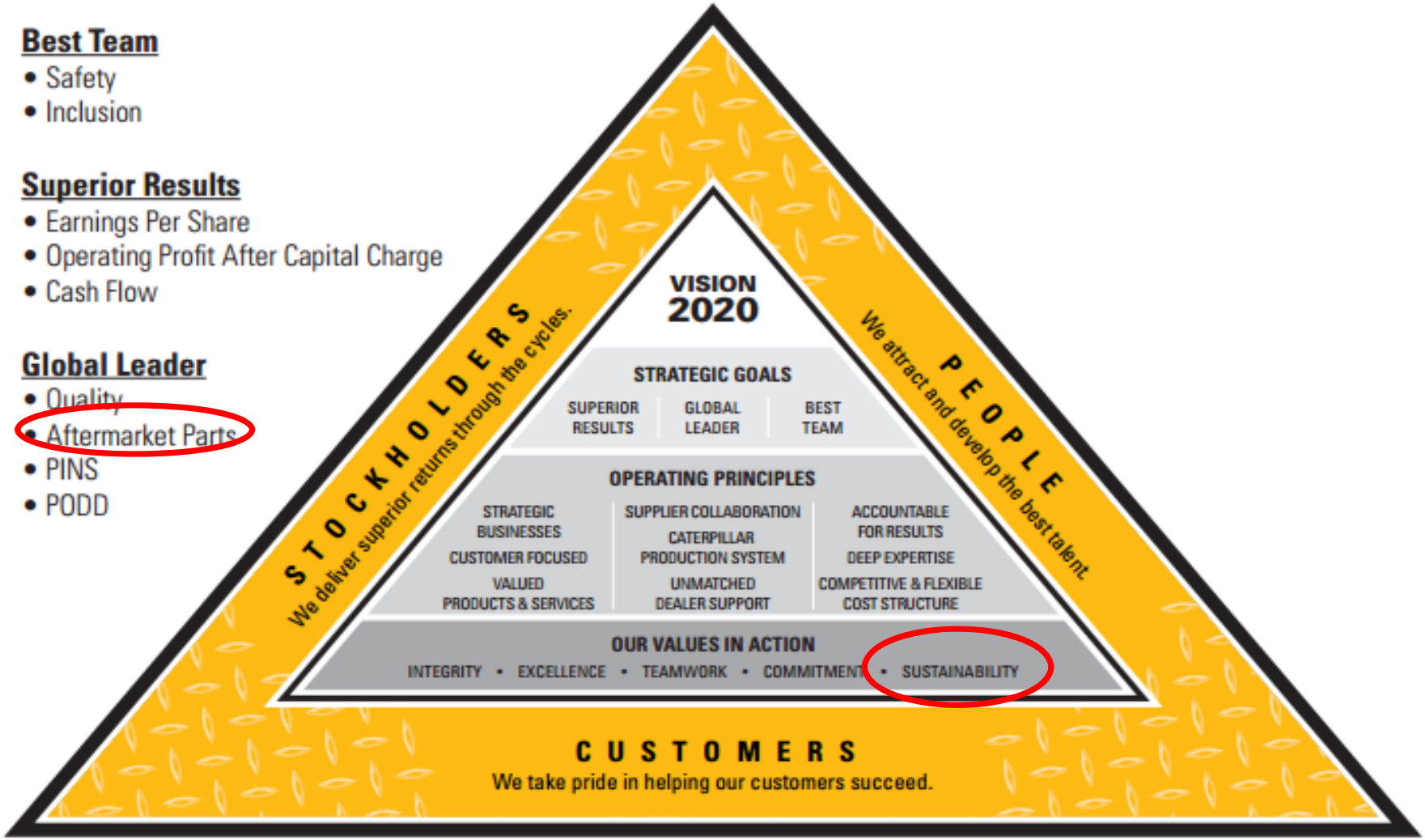
ENTERPRISE STRATEGY

RENEWING OUR STRENGTHS...
...SHAPING OUR FUTURE

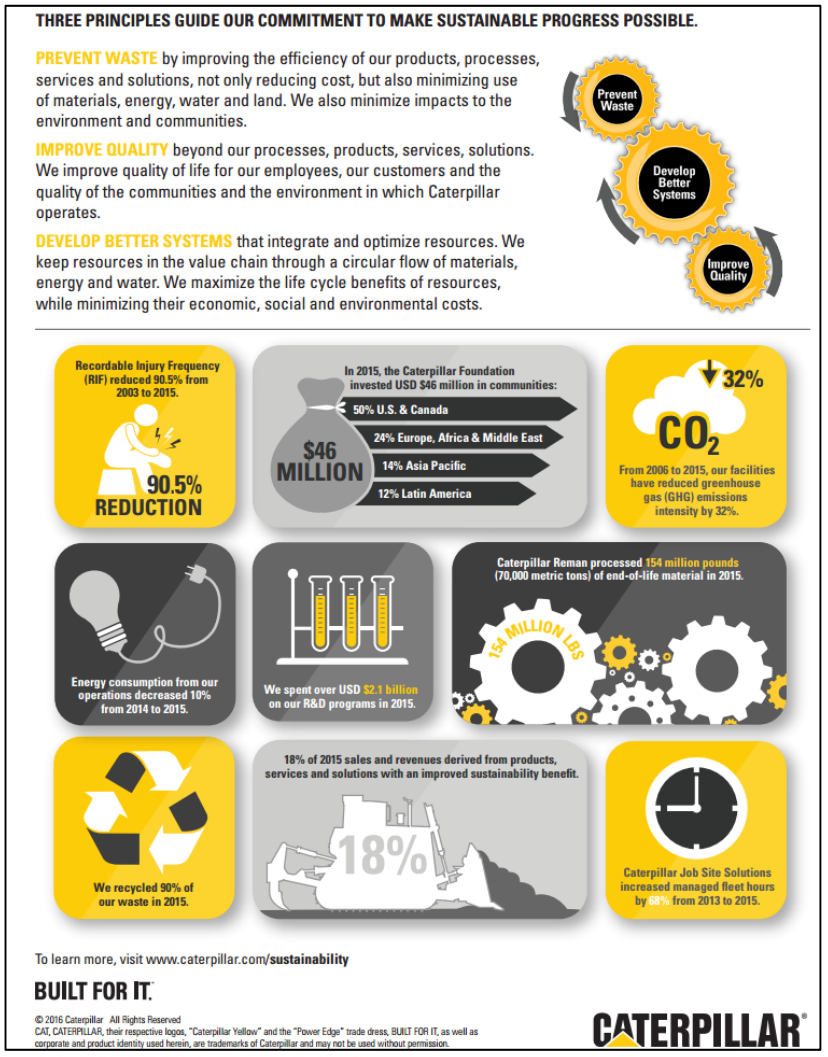
Best Team
- Safety
- Inclusion

Superior Results
- Earnings Per Share
- Operating Profit After Capital Charge
- Cash Flow

Global Leader
- Quality
- Aftermarket Parts
- PINS
- PODD



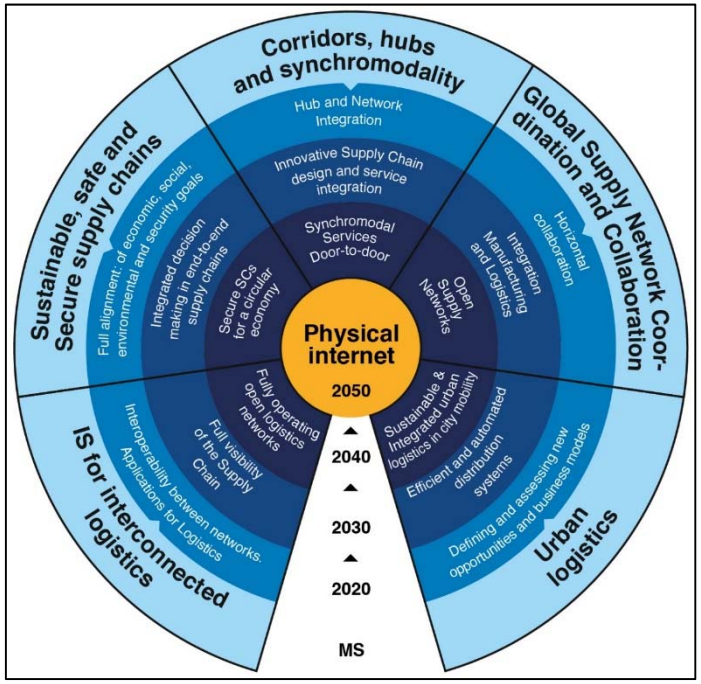
Sustainability is one of our main pillars



Cat Parts transformation Aligns with many elements of PI

The Global Logistics Sustainability Grand Challenge

Design a system
to **move, store, realize, supply** and **use**
physical objects throughout the world
in a manner that is
economically, environmentally and socially
efficient and **sustainable**



Many of our problems overlap…

	Inefficiency and unsustainability symptoms	Economical	Environmental	Societal
✓	1 We are shipping air and packaging	●	●	
	2 Empty travel is the norm rather than the exception	●	●	
	3 Truckers have become the modern cowboys	●		●
✓	4 Products mostly sit idle, stored where unneeded, yet so often unavailable fast where needed	●		●
	5 Production and storage facilities are poorly used	●	●	
✓	6 So many products are never sold, never used	●	●	●
	7 Products do not reach those who need them the most	●		●
✓	8 Products unnecessarily move, crisscrossing the world	●	●	
	9 Fast & reliable multimodal transport is a dream	●	●	●
	10 Getting products in and out of cities is a nightmare	●	●	●
	11 Logistics networks & supply chains are neither secure nor robust	●		●
✓	12 Smart automation & technology are hard to justify	●		●
	13 Innovation is strangled	●	●	●

Cat Parts Distribution: Our Unique Supply Chain Supports Caterpillar's Heritage

- Producing and supporting high-value, durable goods working in time-sensitive, critical environments around the world
- Logistics has always been a Caterpillar core competency

Parts Distribution Network

- 3.2m SKU's, >1M part numbers
  2,000 ship-to points, 3,500 suppliers
- 21 Distribution Centers – 16m ft(2)

- Notable part of Caterpillar's top line
- Slow moving inventory supports a wide and long-lived product line

Caterpillar Parts Distribution Five Major Programs in Motion

Logistics Transformation – Across the Table and Parts Inventory Collaboration (PIC)

Plan for Every Part (PFEP) & Parts Engineered Value Chain (EVC)

Global Footprint and SAP Systems (LEAN)

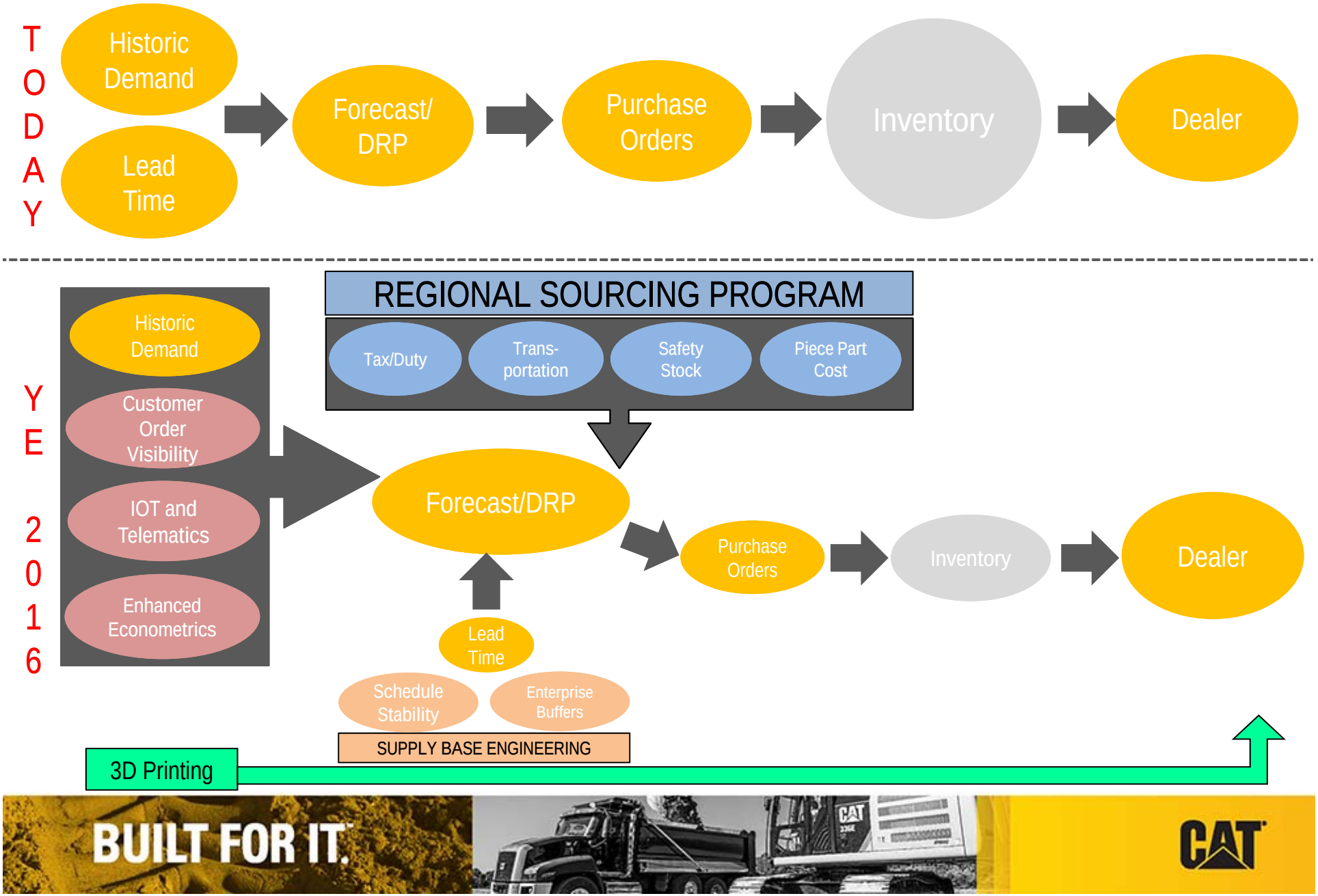
Growth

RUN THE BUSINESS

PFEP

- Plan for Every part (PFEP)
  - Supply base engineering
  - Managed transportation
  - Reducing part number proliferation

PFEP: Total Cost of Ownership



On a Journey to Remove $1 Billion of Inventory from Supply Chain

- Plan For Every Part (PFEP) approach looks at all part-indicative data to optimize buffers, transportation, packaging, distribution density, and inbound processing capability

PFEP Supply Based Engineering Concept

Shorter lead times *reduce variability*

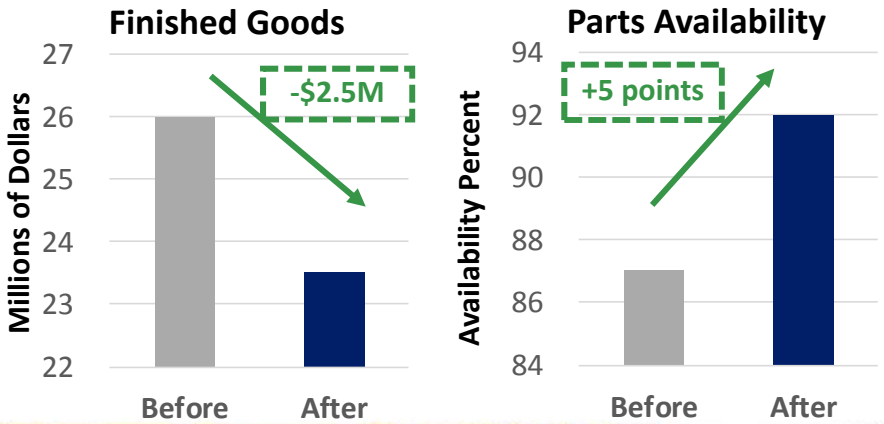
Lower variability means smaller buffers, leading to *improved overall inventory effectiveness*

- Also using advanced software to find similar parts to reduce inventory & avoid creation of new similar parts

Working with Manufacturing, We Realized $2.5M in Savings – On Just a 16 Part Number Pilot

Pilot Program – 16 PN's

- **Problem**: To cover demand variation, product groups were holding substantial WIP inventory
- By analyzing specific components with large lead times, we were able to work with production and optimize buffer stock
- **Results**: Higher availability, better quality, and less schedule variability



Detailed Transmission Example

- **Problem**: A transmission had a 150-day lead time – all product groups were holding safety stock and there was high schedule variability
- After reviewing all of the components in the BOM, we found only *two components were driving the long lead time*
- Results: *Lead times were reduced to 30 days* – production now holds buffer stock on the two parts driving long lead times, not whole assembly
  - Hold castings, but don't machine until needed
  - Requires plants to hold some buffer stock, but at overall savings for the enterprise

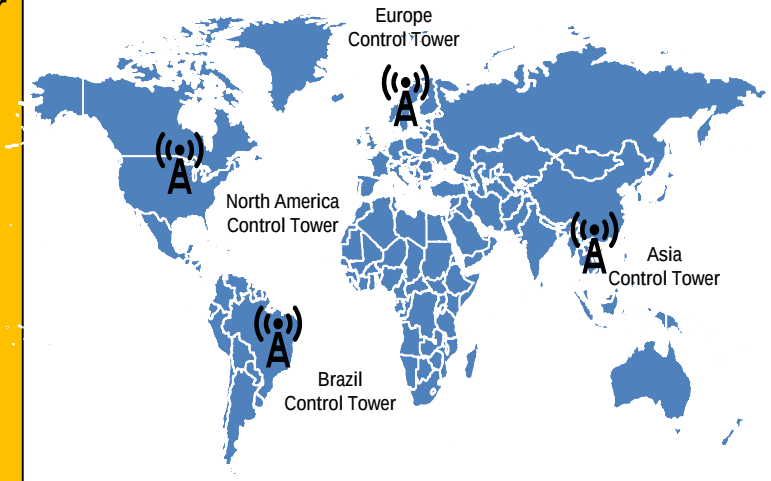
PFEP Common Tool: Managed Transportation

In 2015, Caterpillar was the tenth largest exporter by weight

- ~$1.7B freight spend
- 4.1M tons moved

4 control towers, located in North America, South America, Europe, and Asia managing

- >825,000 shipments
- 8,000 freight lanes



- GMM (Global Material Management) – inbound parts to plants and depots from overseas suppliers
- GTOC (Ground Trans. Ops. Center) – ground movements in N. America, Europe, China, and India
- TLM (Trade Lane Management) – outbound distribution of prime products overseas

Transportation Sustainability Initiatives

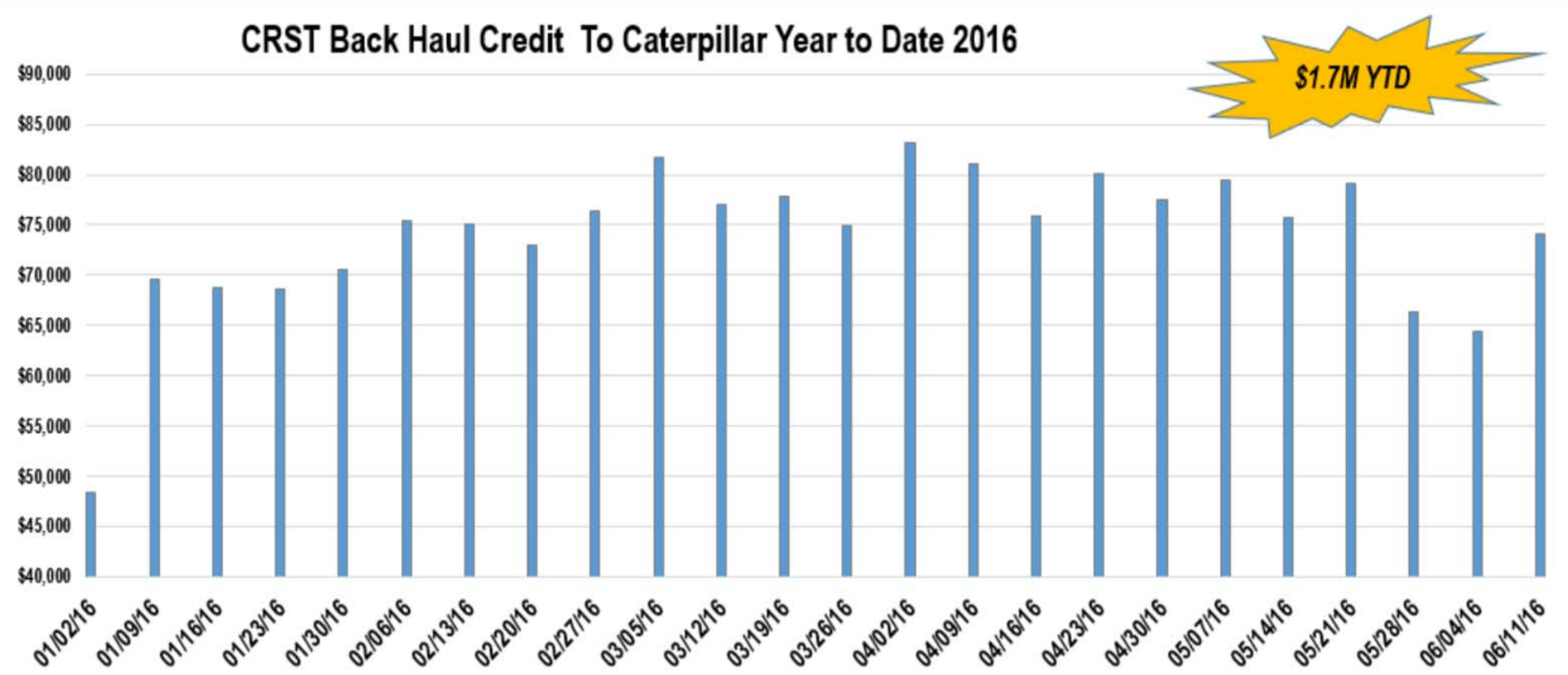
- Utilization & Packaging
- Mode-Shift
- Network Optimization

GOAL: Reduce energy intensity by 50 percent from 2006 to 2020.

GOAL: Reduce greenhouse gas emissions intensity by 50 percent from 2006 to 2020.

GOAL: Reduce by-product materials intensity by 50 percent from 2006 to 2020.

Backhaul Impact on CO2 & Cost



5,500 Metric Tons of CO2 avoidance annually

PI Linkage Summary: PFEP

- Drastic reductions in slow moving inventory
  - Footprint & related costs
  - Lower transportation and CO2
- Less variability in demand/supply signals
  - More transportation leverage “milk runs”/backhaul
  - Highly container density
  - Returnable container options

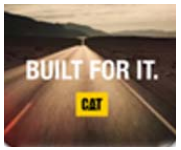
Caterpillar's focus on Internet of Things (IoT)

Enhancement Products Growth

Alternate Distribution for Electronics

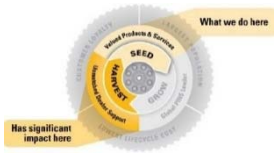
Multi-Tiered Rebuild Strategy

Scrap Governance



Deliver Brand Promise

Rationalizing D's (slow moving parts)



Aftermarket Parts Protection and Growth

Product Information Management (eCommerce)

Cat Connect - IoT

Caterpillar's Sensor and Telematics Presence: Uptime and low cost of ownership

Productivity

Fuel Burn/Flow Measurement/Theft Detection
Operator ID
Payload Monitor/Measure
Worktool Tracking
Remote Disable
PL Basics, Location & Hours

Safety

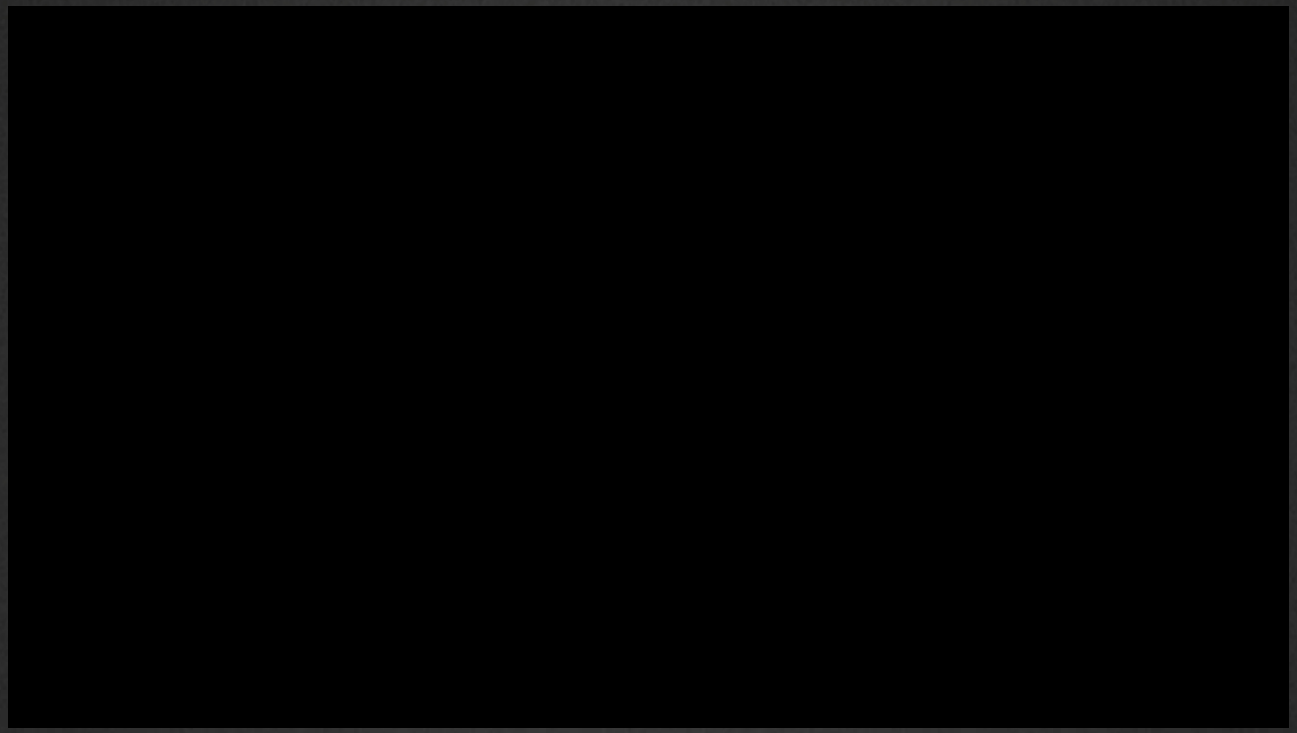
Camera Systems & Radar
Work Lights
Seat Belt Reminder & Beacon
Personnel Detection
Fatigue Monitoring
Tire Pressure Monitoring
Cabin Air Quality

Maintenance

Battery State of Charge
Fuel Level & Quality Sensing
Case Drain Monitor
Filter Life Monitor (Fuel/Oil/Air)

Our motor graders equipped with Cat Grade Control leverage satellites 12,000 miles away to automate the cutting blade to centimeter accuracy

We have fleets of these 1.4m pound trucks running autonomously….




BUILT FOR IT.
CAT
CAT

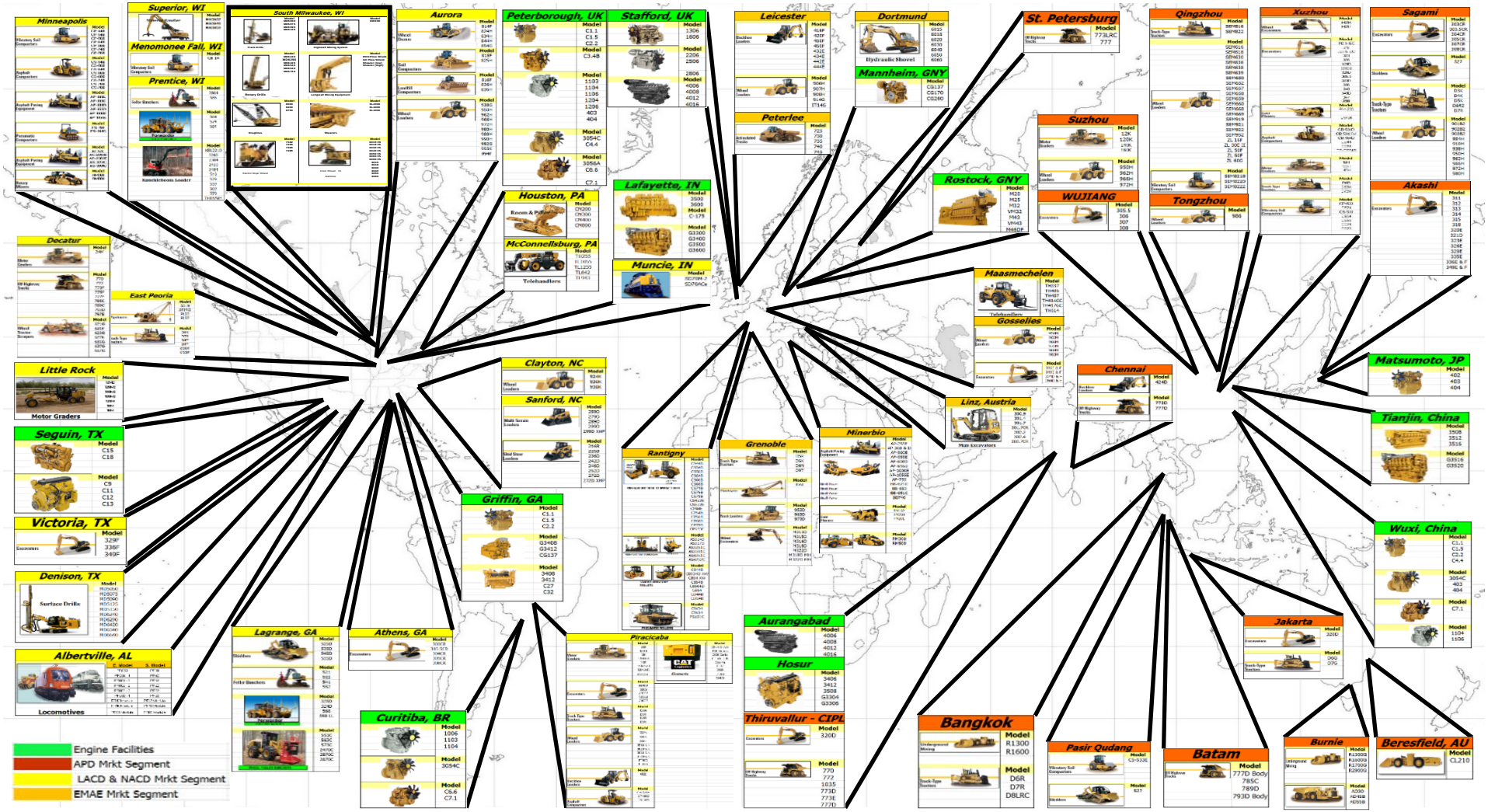
PI Linkage Summary: IoT

- Add value for our customers
  - Higher up-time by having the right parts available – less expediting
- Improved stocking decisions at Caterpillar and our dealers
  - Footprint & related costs
- Lower transportation and CO2
- Less variability in demand/supply signals through proactive failure management
  - Better global resource utilization

Regional Sourcing Concept

- Source material closer to demand
  - Utilize new sources developed by manufacturing facilities in low cost countries
  - Buying direct from manufacturing plants in developing countries
  - Competitively source parts globally
- Requires a Total Cost of Ownership view to make the decision
  - Network safety stock impact – how many places do we hold buffer inventory & impact of much shorter transit times
    - Direct Ship opportunities
  - Material cost differences – leverage low cost producers IF they can provide expected quality & delivery performance
  - Tax and Duty impact can be a significant win
  - Transportation – drastic reductions as supply/demand are in proximity

Global Model Sources Opportunity:
Regional Sourcing in Asia Pacific started 2015



Example 1 – India: ADC IPC enabled India and ASEAN sourced parts to be regionally processed

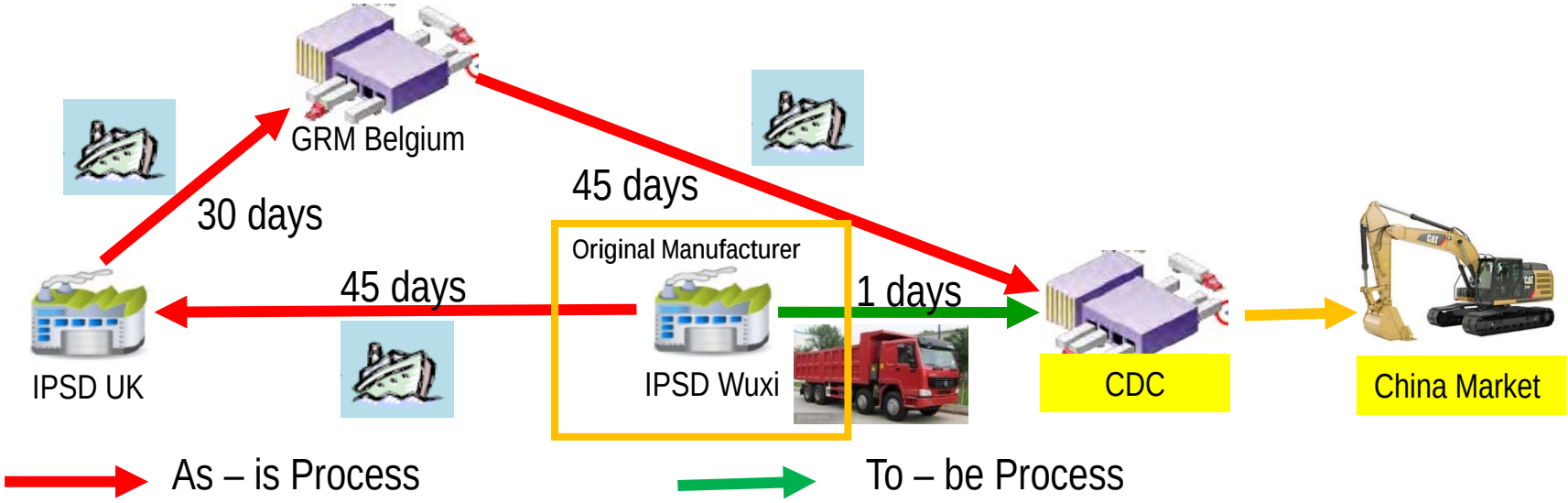
- 1600 lb Spindle sourced from India, received at Grimbergen, then shipped to Singapore for APD demand.

Regionally received and Packaged in Singapore:

- -40% Packaging Cost reduction
- -28,365KM less travel
- -reduced transit time ~ 50 days
- -$325k TCO savings

In Region receiving Improve Operation Efficiency Reduce cost.

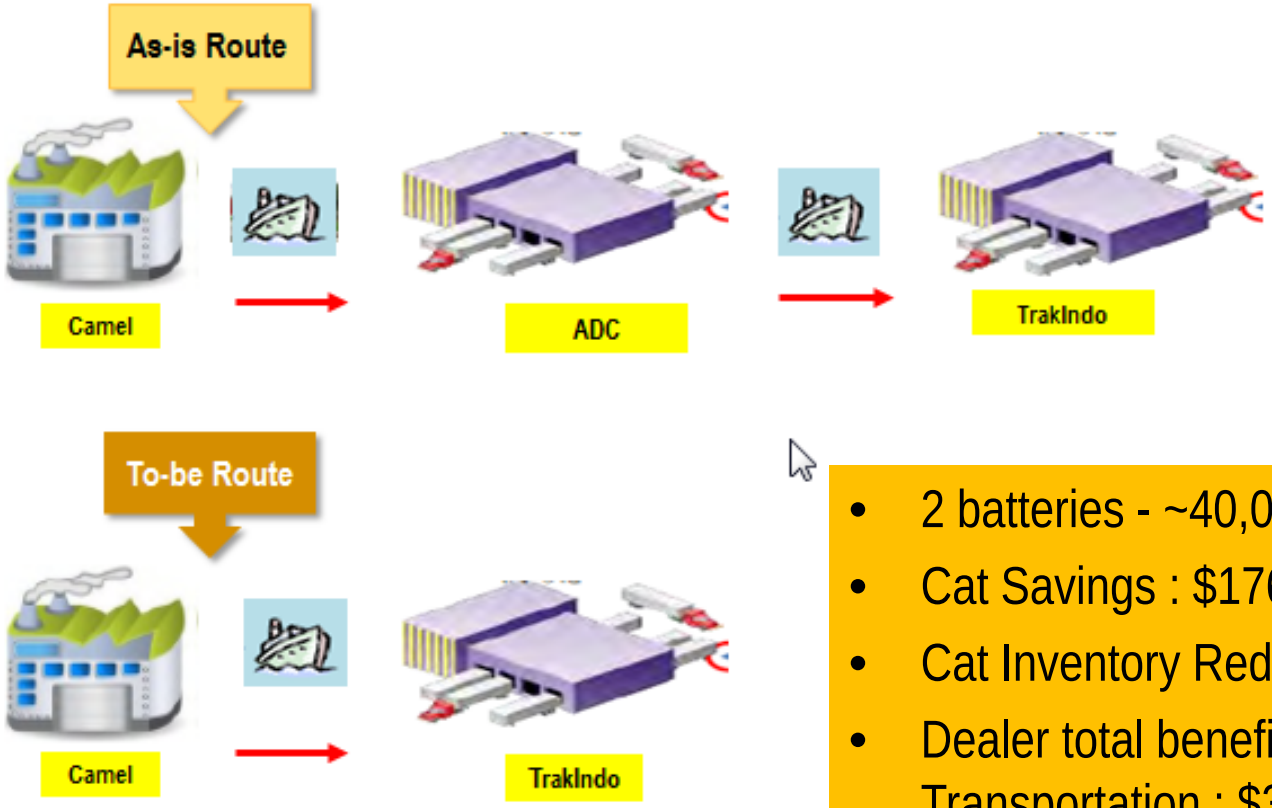
Example 2 – Wuxi: Service Engine Source Change from IPSD UK to IPSD Wuxi



1. Reduce transit time 120 days to 1 days
2. Avoid in-transit stock and inventory on hand at Grimbergen DC
3. Significant reduced transportation cost avoid potential Air freight for emergency orders
4. Avoid import duty (8.4% based on “intercompany cost + transportation cost to CDC”)
5. Improve parts availability & customer satisfaction

Inventory Avoidance: $500K
TCO Benefits: $350K

Example 3: Direct Ship China to Indonesia



- 2 batteries - ~40,000/year in region
- Cat Savings : $176,000
- Cat Inventory Reduction : $582,000
- Dealer total benefit including Transportation : $375,000
- Full Container Load shipment
- Reduced scrap – longer useful life

PI Linkage Summary: Regional Sourcing

- Improved stocking decisions at Caterpillar and our dealers
  - Footprint & related costs
- Lower transportation and CO2
- Less variability in demand/supply signals
  - Better global resource utilization
- Drives Direct Ship opportunities from supplier to dealer
  - Transportation and expired/waste reduction

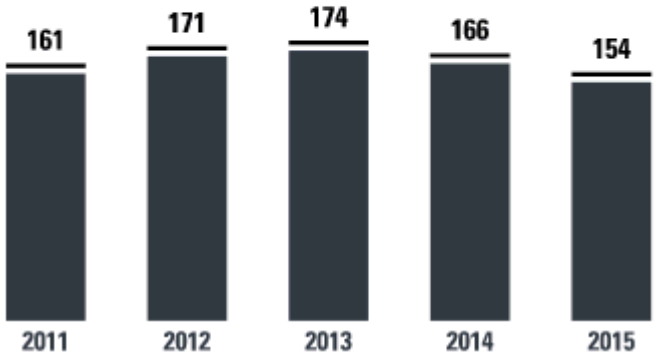
Remanufacturing

For over 40 years, Caterpillar has encouraged circular economy principles through our remanufacturing and rebuild businesses

- This starts with durable products, many designed to be rebuilt multiple times
- Components and machines are overhauled, rather than simply repaired or replaced
- Drives some of our greatest contributions to sustainable development by keeping nonrenewable resources in circulation for multiple life cycles.

REMAN END-OF-LIFE "TAKE-BACK" BY WEIGHT[1]

Millions of pounds of end-of-life material received



Vision

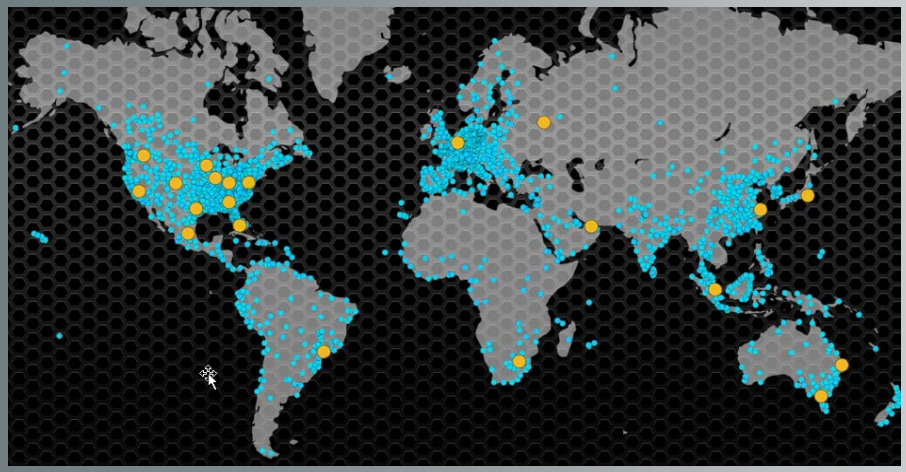
Leverage one integrated network to deliver

CONSISTENT PREMIUM PARTS AVAILABILITY

leading the industry in cost efficiency and asset utilization

Measure of Customer Success

On Time In Full



- **Parts Inventory Collaboration**
  - Data sharing/integration
  - Parts policies to incent collaboration
  - Dealer deployment
- **Reduce breadth of dealer AND Caterpillar inventory**
- **Goal: On Time In Full**

Additive Manufacturing – Wouldn't it be Cool if…

Parts of our warehouses looked like this…

"…It's just another manufacturing method."

Mobile Printing

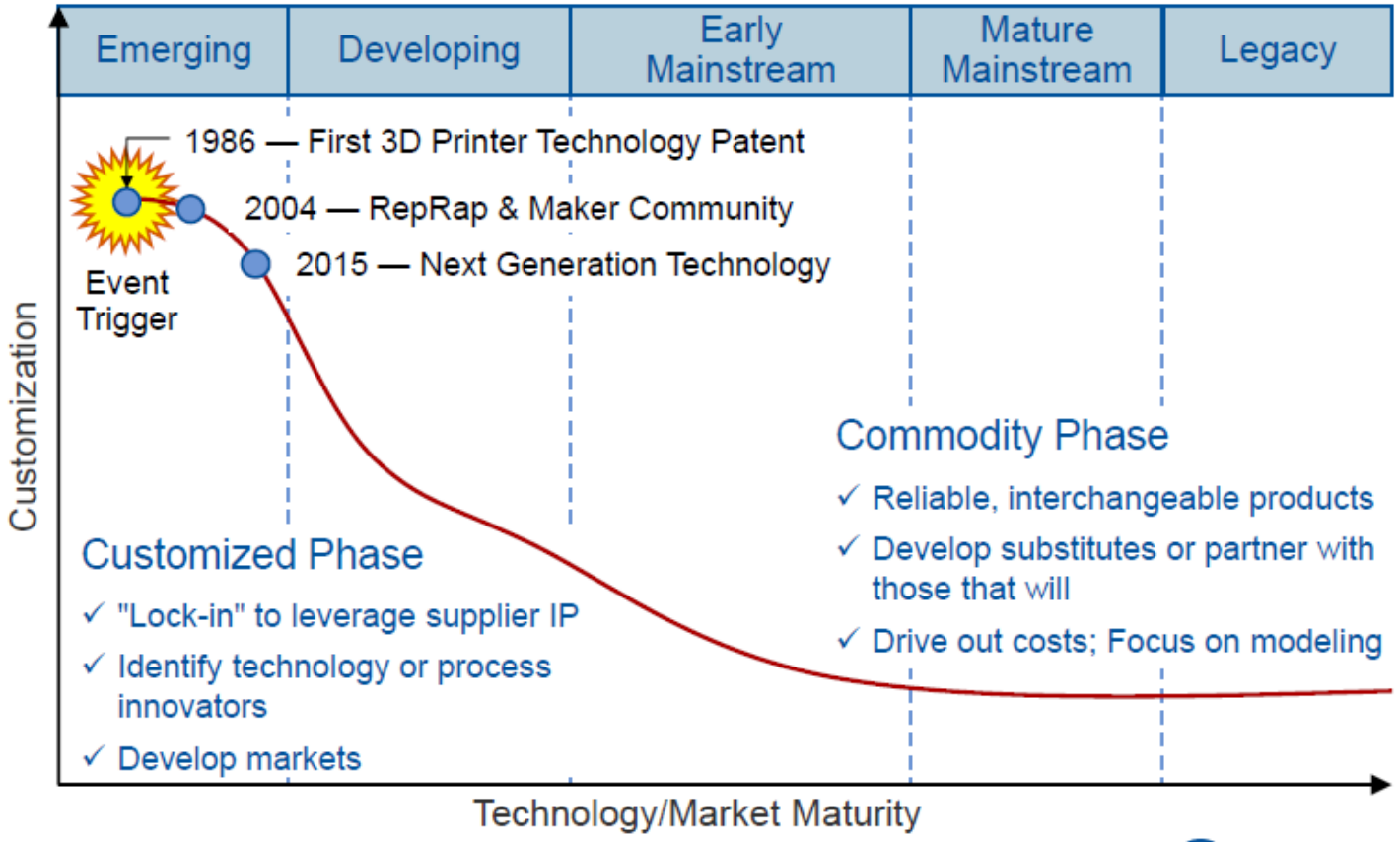
Point of Use Printing

We could print parts at the counter

Accelerated Cat Engineering Manufacturing Cycles

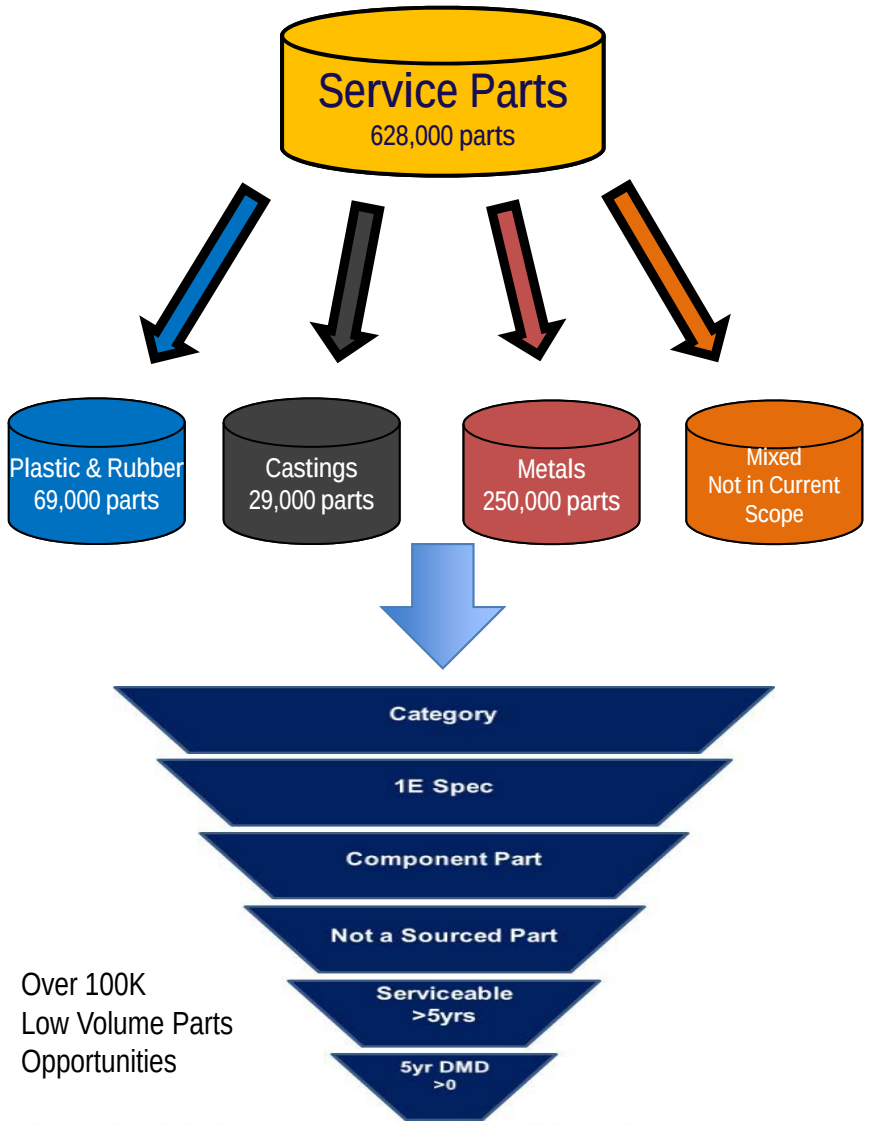
Gartner says, “ 3D Printing is still emerging, there are risks involved”

3D Printer Commoditization Curve



Gartner

3D Printing Opportunity for Service Parts



Over 100K
Low Volume Parts
Opportunities

•Could we print it?

• Identifying Show Stoppers	•Technical Validation
	•Legal Rights - IP
	•Supplier Agreement

•Should we print it?

•Business Cases •Portfolio / Use Cases •Customer Needs	•Reduce Inventory	•Per Piece Savings
	•Improve Availability	•Minimum Buy Savings
	•Reduce Supply Chain Costs	•Inventory Position
	•Avoid Tooling Costs	•Early Life Cycle

Risks

- Lack of Enterprise funding to support 3D
- Internal sign-off and validation processes
- Technology capabilities
- Engineering cost
- Validation cost
- Make vs. buy
- Quality
- Supplier management
- Bottleneck in validation

Putting manufacturing process into distribution adds significant complexity – for example:

- Job classification changes
- Zoning, bonded vs. non-bonded
- Intellectual property owned by supplier
- Tax and trade implications
- Hazardous material disposal
- Environmental controls
- Space
- Raw material management
- Quality and process controls
- Security – physical and system
- Accounting and IT systems to manage
- Post-production processing equipment required

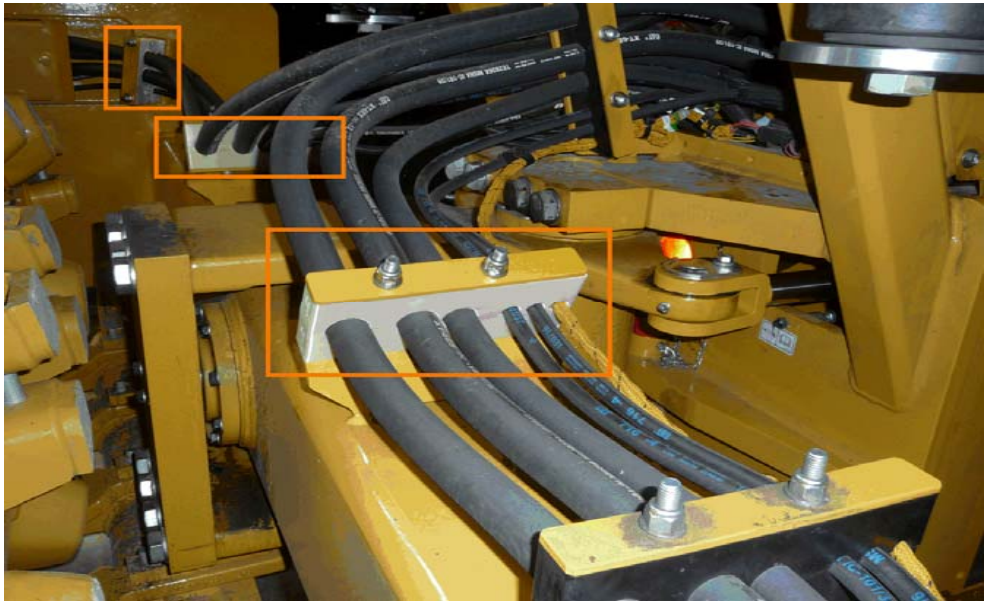
Lessons Learned – Aluminum Fuel Base Assembly

- Background: Supplier went out of business and we had a 4-month lead time to set up supplier and transfer tooling
- 3D printing offered lead time reduction to bring a customer machine online
- Part was laser sintered aluminum… took 100 hours and 200x traditional cost
- Size problem: Blueprint to printer didn't provide tolerance for post processing
- Technology worked – part passed validation tests

14”

Lessons Learned – Hose Clamp

- 5 different hose clamps tested across 3 different NPI machines (500 hour testing)
- 325 hours into the test – All looked good
- Between hour 325 – 500 cracks occurred in clamps
- Large part opportunity with validated clamps
- Failure analysis being performed and clamps will be re-designed for future testing



Lessons Learned - Investment Casting to 3D Printing

- **Background:** Opportunities to reduce prototype cycle time and ability to reduce tooling costs
- **Printing and Validation**
  - Part not possible with traditional manufacturing
  - Reduced injector manufacturing prototype cycle time from 12 months to 6 weeks by utilizing additive technology
  - Engine Validation Test was completed successfully
  - Moving to production using Additive Manufacturing technology

Additive Manufacturing Technology

Status

- More materials research is needed
- Faster engineering validation processes required
- Must be embedded into new product engineering cycle
- Post-processing is a huge hurdle
  - Costly
  - Blueprint changes
- Big wins on prototyping
- IP protection, disenfranchising potential are huge hurdles

PI Linkage: 3D printing

- Drastic reductions in slow moving inventory
  - Footprint & related costs
  - Eliminates transportation and CO2
- Less waste from engineering changes “orphaning” parts
- Packaging reduction – direct to shop floor

Summary: Sustainability in three dimensions

- Environmental:
  - Fuel/GHG emissions reductions
  - Material use reductions (& energy associated with mfg, plus reduced disposal)
  - Packaging reductions (waste)
- Social:
  - Employee development/training for new jobs and/or use of new technology
  - Community impacts: development of new economic opportunities in developing countries
- Economic:
  - Huge cost savings
  - Drives business growth through reduced cost/price
- Difficult to keep up with pace of changes
  - IoT
  - 3D printing
- Caterpillar is interested in exploring benchmarking & idea exchange

Questions?