KNORR-BREMSE

CUST 125 - A Journey from Drawing Pictures to Model-Based Systems Engineering and Development

Nashville TN
June 8th, 2015
Rev A

Debora Elam

Agenda

- Company
- Journey
- Questions

Knorr-Bremse is the world's leading manufacturer of braking systems for rail and commercial vehicles

Rail Vehicle Systems

- Metros
- Streetcars
- Multiple units
- High-speed trains
- Locomotives
- Passenger rail cars
- Freight cars

Commercial Vehicles

- Trucks
- Buses
- Engines
- Special vehicles

Knorr-Bremse has 87 sites on all continents in 27 countries. 56 of them are manufacturing locations.

America

- Brazil
- Canada
- Mexico
- USA

Europe/Africa

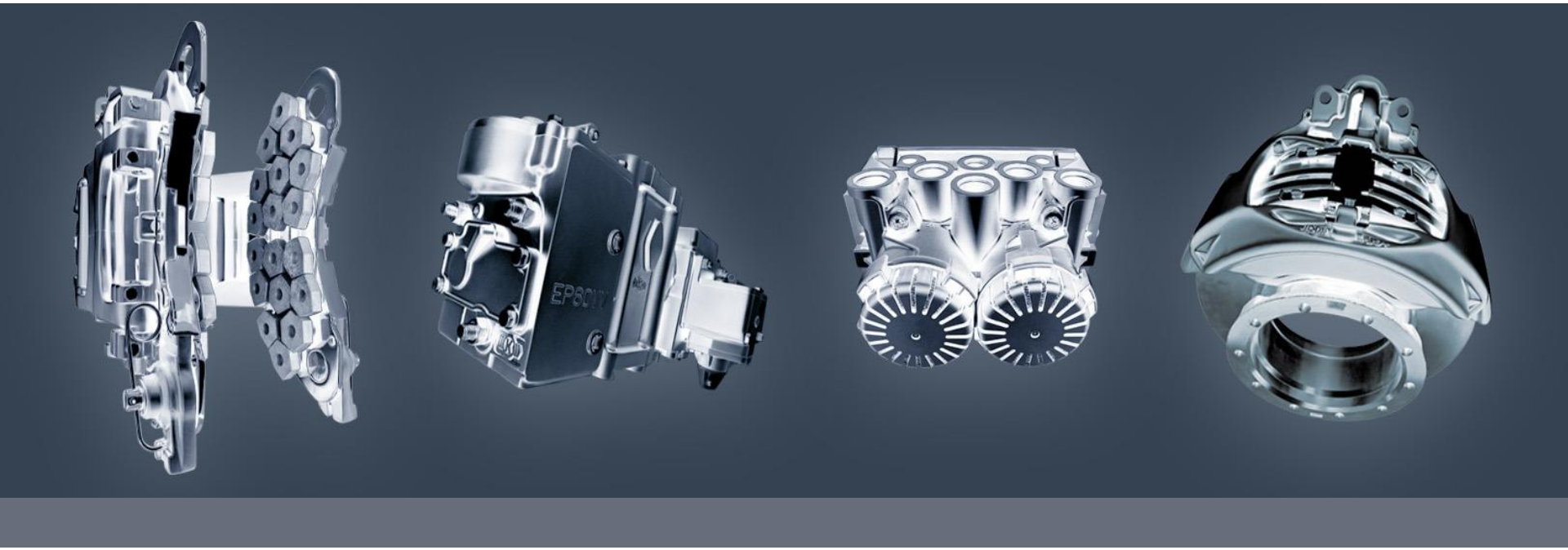
- Belgium
- Germany
- France
- UK
- Italy
- Netherlands
- Austria
- Poland
- Romania
- Sweden
- Switzerland
- Spain
- Czech Republic
- Turkey
- Hungary
- South Africa

Asia/Pacific

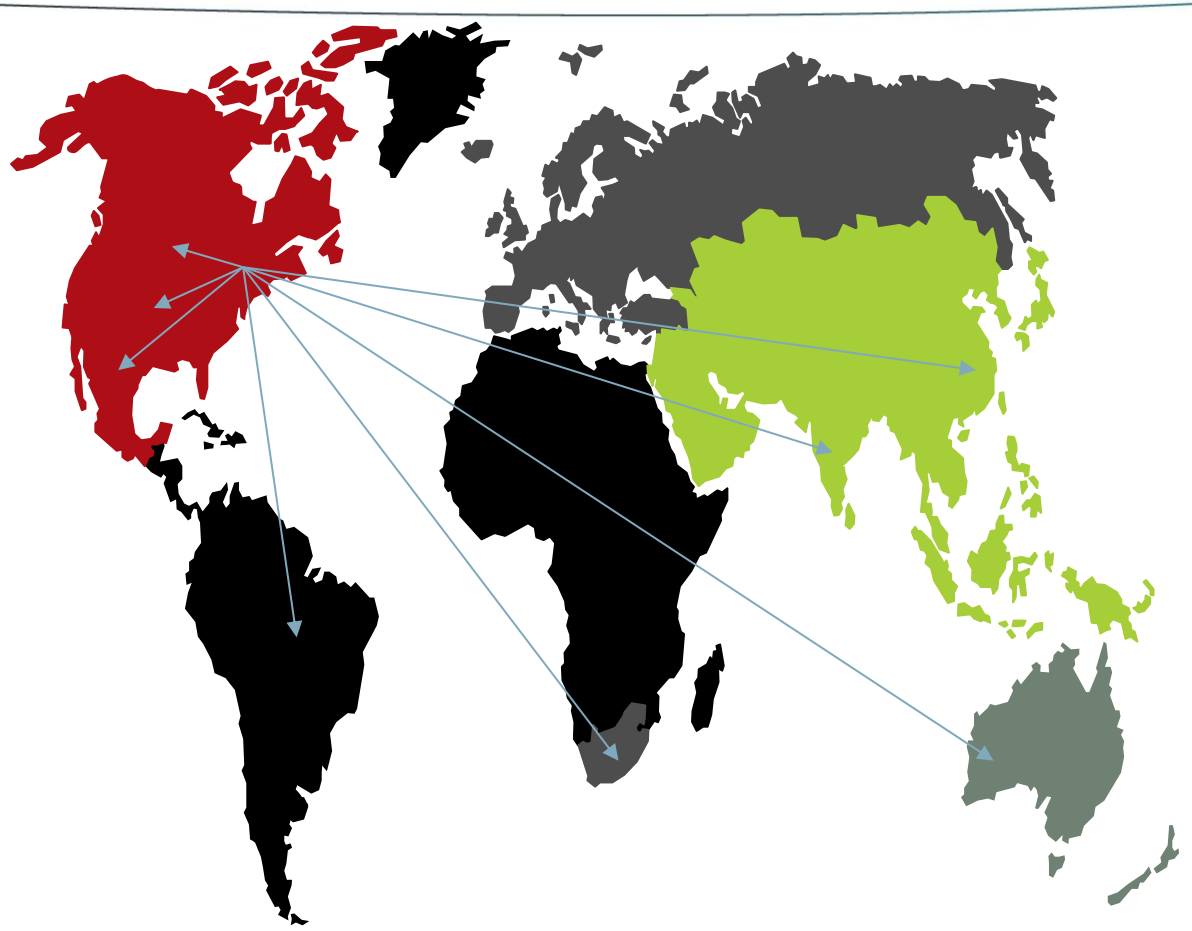
- Australia
- China
- India
- Japan
- Russia
- South Korea
- Singapore

KNORR-BREMSE

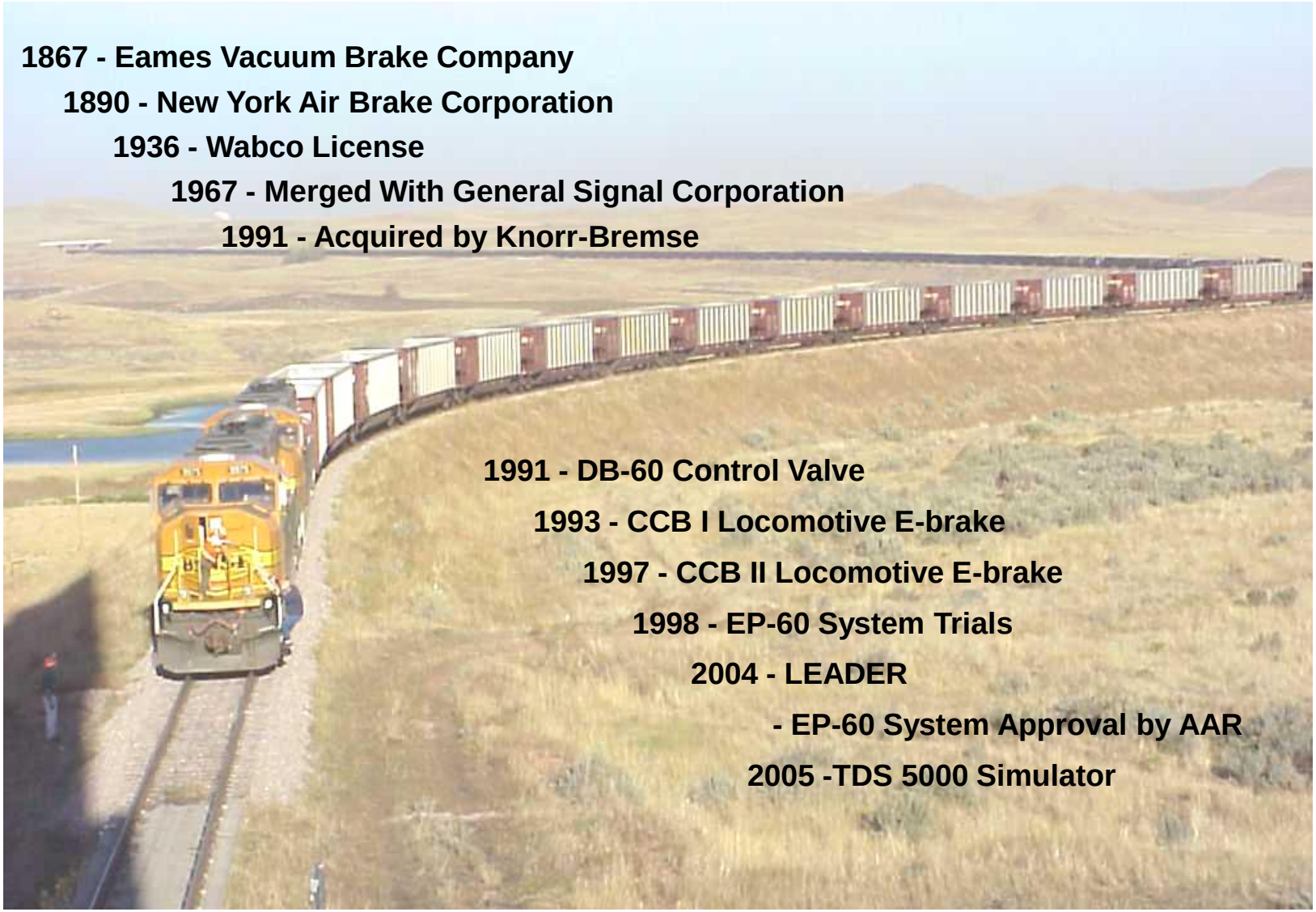
New York Air Brake Overview



NYAB Center of Competence
AAR Heavy Haul Products



NYAB History



1867 - Eames Vacuum Brake Company

1890 - New York Air Brake Corporation

1936 - Wabco License

1967 - Merged With General Signal Corporation

1991 - Acquired by Knorr-Bremse

1991 - DB-60 Control Valve

1993 - CCB I Locomotive E-brake

1997 - CCB II Locomotive E-brake

1998 - EP-60 System Trials

2004 - LEADER

- EP-60 System Approval by AAR

2005 -TDS 5000 Simulator

NYAB Profile

Customer Focus

- The Right Products and Services
- Beating Expectations
- Delivering Value
- Driving Customer Success

New Product Development

- Broad Engineering competence - Pneumatic, Electronic, Mechanical, Software
- Advanced Test Lab

Manufacturing / Operations

- Freight Wagon Equipment – Capacity 35,000 systems
- Locomotive Electronic Brake – Capacity 1,200+ systems

Quality

- ISO 9001, IRIS
- Six Sigma

NYAB - Locations

Watertown, New York
580 Employees
225,000 Sq.Ft. Facility
20,000 Sq. Ft. Test Lab

Headquarters, Marketing & Sales
Engineering & Innovation
Manufacturing – Wagon and Loco

Kingston, Ontario, Canada
25 Employees
25,000 Sq.Ft. Facility

Service, Repair and Distribution – Canada

Dallas, Texas
115 Employees
25,000 Sq.Ft. Facility

Innovation: Driver Training Simulators
LEADER Driver Information System

Kansas City, Missouri
100 Employees
30,000 Sq.Ft. Facility

Service & Repair

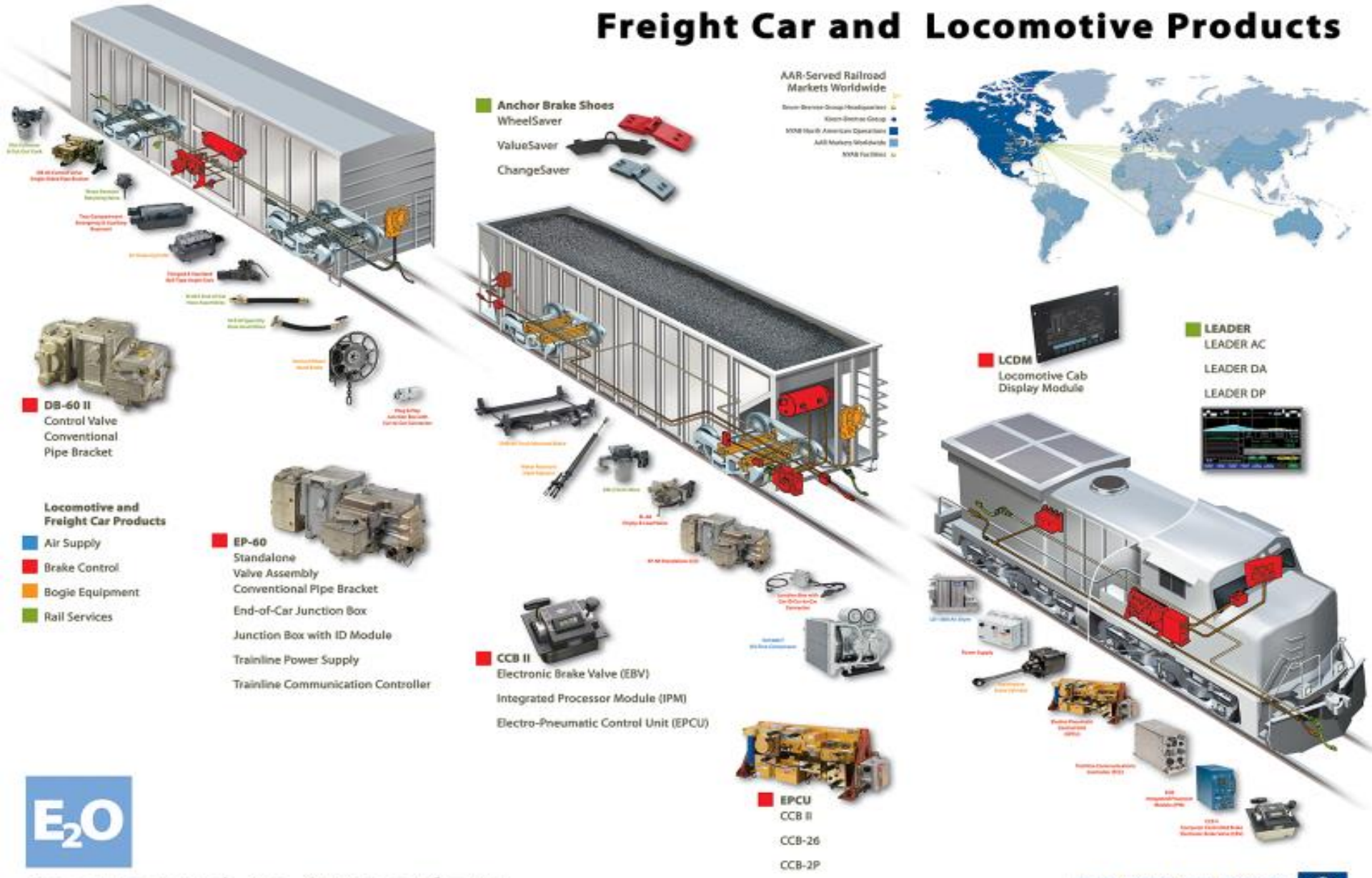
Anchor Brake Shoe (Chicago, Illinois)
70 Employees
50,000 Sq.Ft. Facility

Manufacturing – Brake Shoes

Premtec (China Grove, North Carolina)
40 Employees
15,000 Sq.Ft. Facility

Manufacturing - Hoses

NYAB Products



E2O

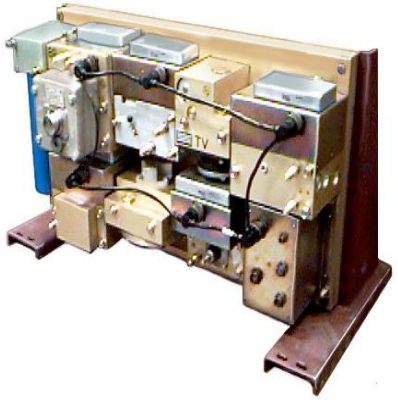
Engineered to Outperform

NEW YORK AIR BRAKE

NYAB - Products

New Technology Products

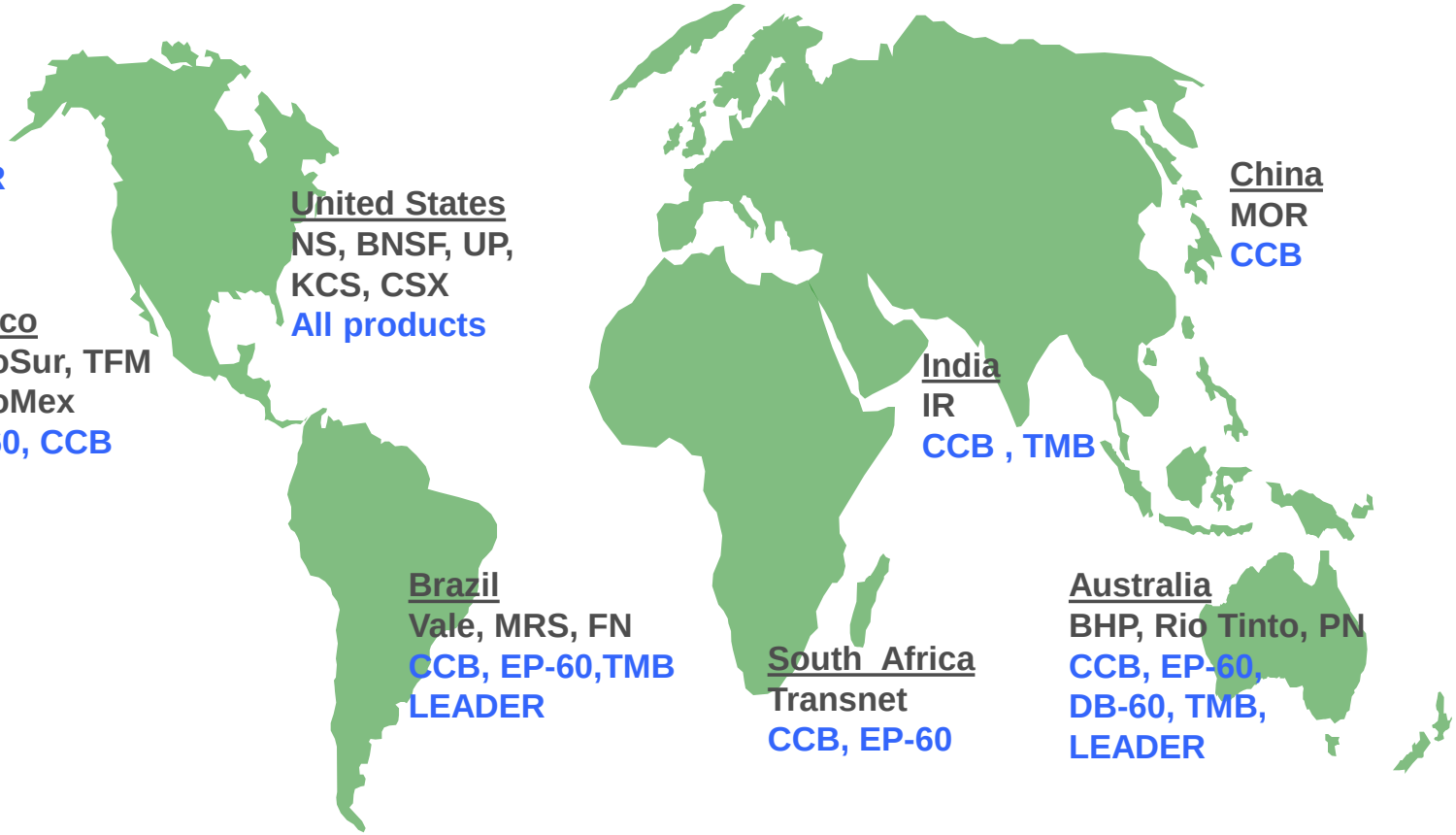
- EP-60 Electro-Pneumatic Brake System
- VV1000-T Oil Free Compressor
- HVAC and Dampers



Core Products

- CCB II and CCB 26 Locomotive Brake Control
- DB-60 Control Valves
- TMB-60 Truck Mounted Brake
- EL-60 Range
- Brake Hoses
- Brake Shoes

Worldwide Customers



Canada
CP, CN, QCM
EP-60, CCB
TMB, LEADER
DB-60, TDS

United States
NS, BNSF, UP,
KCS, CSX
All products

Mexico
FerroSur, TFM
FerroMex
DB-60, CCB

China
MOR
CCB

India
IR
CCB , TMB

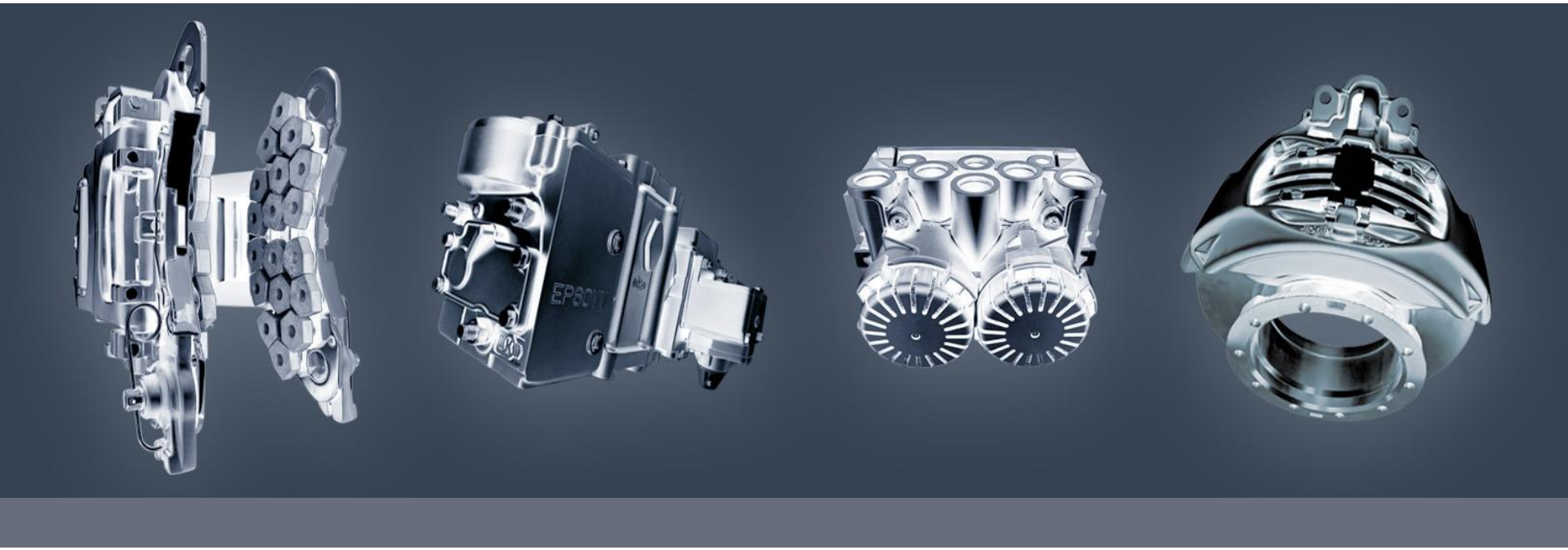
Brazil
Vale, MRS, FN
CCB, EP-60,TMB
LEADER

South Africa
Transnet
CCB, EP-60

Australia
BHP, Rio Tinto, PN
CCB, EP-60,
DB-60, TMB,
LEADER

KNORR-BREMSE

New York Air Brake Software and Systems Modeling



Model Driven Engineering Paradigms

Software Engineering

- Model Driven Development
- Model Driven Software Development
- Model Driven Architecture

Systems Engineering

- Model Based Systems Engineering

Model Driven Engineering Paradigms

Benefits

- Manage complexity
- Visualization to help identify missing elements
- Depict and understand tradeoffs
- Trace from the "what" to the "how"
- Navigate seamlessly ("Google Earth" concept)
- Improve communication with stakeholders
- Standardize means to convey the design
- Reusability of elements
- Manage variability and configurability
- Automate
  - Avoid rework and eliminate time lost in brainlessly updating documents
  - Avoid errors through model consistency
  - Verify and test the design
  - Generate executable code

Journey

Objective

- Improve design

Timeline

- Key milestones

2005 – 2006 – 2007 – 2008 – 2009 – 2010 – 2011 – 2012 – 2013 – 2014 – 2015

- 2005: Kick-off
- 2009: Model Simulation Pilot
- 2011: Reduced maintenance support
- 2013: Re-commitment

Journey

Kick-off

- Project to identify and rate requirements, and compare UML CASE tools
- Team recommendation vs. management decision
- Pilot effort and roll-out

Model Simulation Pilot

- New product with relatively simple inputs and outputs
- Multiple simulation models to walk through the state machine
- Front-end GUI to simulate physical elements

Reduced Maintenance Support

- ROI concerns

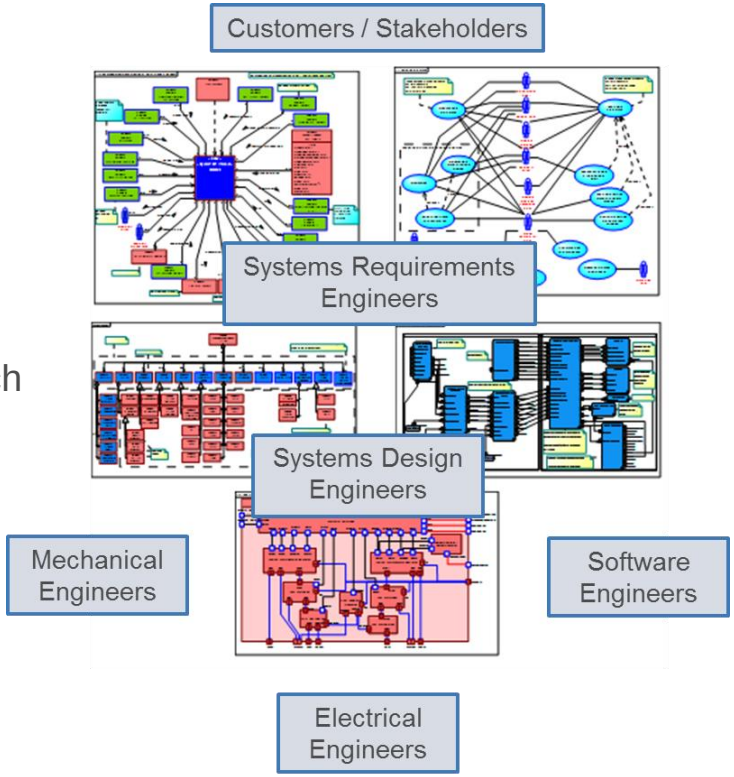
Re-commitment

- Windows 7 upgrade
- Next generation product development
  - MBSE and code generation
- Engineering IT vision of an integrated ALM and PLM system

Journey

Accomplishments

- Software
  - Custom code generator for our unique processor
  - Code generated from the model for a next generation product
- Systems
  - Next generation product systems design using MBSE approach
  - Foundation set for better PLE of new products



Benefits Realized to Date

- Improved communication on a global collaborative level
- Improved reliability architecture decisions
- Reduced document maintenance
- Better support for agile development
- Provides context for the system and its elements
- Decreased development time to date
  - Standardized diagrams, templates, profiles, etc.
  - Reduced coding time
- High confidence we will end up with a quality product that meets the business and customer needs

Engineered to Outperform
E2O
NEW YORK AIR BRAKE

Journey

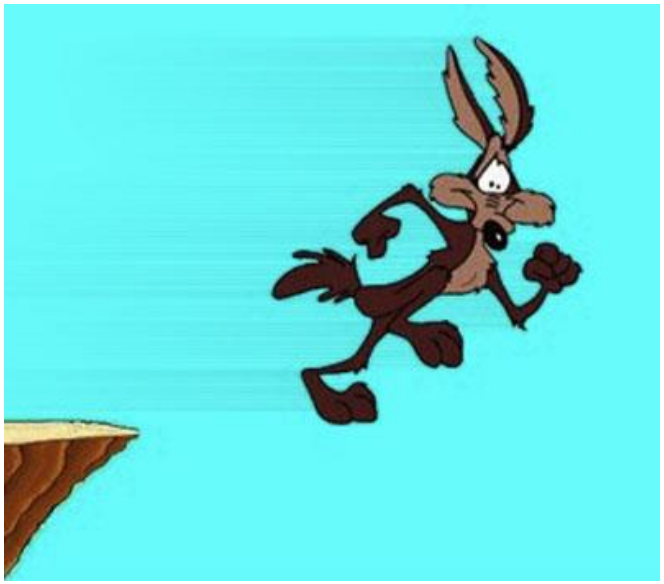
Challenges

- Maturity of model driven engineering and the tools is limited
- Integration and inter-operability of the tools still a work in progress
- High costs
  - Tools, training and infrastructure resource needs
- Return of investment (ROI)
  - Upfront costs are easy to determine, but total product cost and value gained is not
- Change
  - New paradigm for software and systems engineering
  - Organizational, and roles and responsibilities implications
- High learning curve
- Customization
  - Nothing is just right out of the box
- Modeling vs. drawing
- Modeling new vs. legacy

Journey

Lessons Learned (again)

- Need full buy-in and commitment
- Invest in infrastructure, resources, **AND** training
- Upfront skills needed
  - UML
  - SysML
  - Design
- Walk before you run
  - Pilot
- Communicate often
- Leverage the experts
- Consider SME roles



Thank You for Your Attention

NEW YORK AIR BRAKE CORPORATION
748 Starbuck Avenue
Watertown, New York, 13601
Phone: +1 315 786 5200
Fax: +1 315 786 5676
http://www.nyab.com