U.S. Manufacture of Rail Vehicles for Intercity Passenger Rail and Urban Transit

A Value Chain Analysis



June 24, 2010

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CENTER ON GLOBALIZATION Governance & Competitiveness

This research was prepared on behalf of Apollo Alliance with support from the Rockefeller Foundation and Surdna Foundation. The authors would like to thank Matt Mayrl of the Apollo Alliance for comments on early drafts. Many thanks also to the following reviewers: Doug Bowen, Chandra Brown, Nora Friend, Ruggero Golini, Dennis Harwig, Hatsuhiko Kageyama, Mike Mekhiche, Richard Moss, Matthew Palilla, Mike Pracht, Maryanne Roberts, Robin Stimson, and Chuck Wochele. Errors of fact or interpretation remain exclusively with the authors. We welcome comments and suggestions.

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List of Abbreviations

APMs	Automated People Movers
ARRA	American Recovery and Reinvestment Act
CNR	China North Locomotive and Rolling Stock Industry Group
CSR	China South Locomotive and Rolling Stock Industry Group
DMUs	Diesel Multiple Units
EMUs	Electric Multiple Units
EMD	Electro Motive Diesel
EWI	Edison Welding Institute
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HSR	High Speed Rail
IAMAW	International Association of Machinists
IBEW	International Brotherhood of Electrical Workers
LRT	Light Rail Transit
NAICS	North American Industry Classification System
OEM	Original Equipment Manufacturer
PRIIA	Passenger Rail Investment and Improvement Act of 2008
UNIFE	Union des Industries Ferroviaires Européennes
U.S. PIRG	Federation of State Public Interest Research Groups

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Executive Summary

Since the 1950s, the United States has invested far more heavily in highways and air transport than in rail transportation. There are signs, however, that the nation is beginning to step up its commitment to rail by increasing funds for intercity passenger rail (Amtrak) and urban transit rail (metros, light rail and streetcars). The 2009 American Recovery and Reinvestment Act (ARRA) provided a total of $17.7 billion for transit (including bus transit) and intercity rail programs combined,[1] including $1.3 billion for Amtrak and $8 billion for new high-speed rail corridors and intercity passenger rail. These are small investments compared to those in other countries with well-developed rail systems, but they constitute a watershed in the nation's commitment to passenger rail, and they have been presented as a "down payment" on future investments (White House, 2010). Similarly, current proposals for the much-anticipated renewal of the nation's six-year surface transportation bill call for significantly greater commitments to public transit, including rail.

If the United States is to increase its investment in passenger rail and transit rail, several important questions arise: How much of the required "rolling stock"—the passenger locomotives and railcars—will be manufactured in the United States? What gaps in the current U.S. supply chain need to be filled? What are the relevant opportunities for U.S. manufacturing?

To determine the extent of U.S. manufacturing potential and show where it lies, we mapped out the U.S. supply chain for six rail types: intercity passenger, high speed, regional, metro, light rail, and streetcars.

Key findings:

<u>1) The supply chain includes at least 249 U.S. manufacturing locations in 35 states</u>. We identified a total of 15 railcar builders, 5 locomotive builders, and 159 Tier 2 systems and component suppliers with relevant U.S. manufacturing locations. These ranged from small firms with fewer than 20 employees and only one manufacturing site, to large, diverse firms with thousands of employees and several relevant U.S. manufacturing locations.

<u>2) While U.S. domestic content rules have ensured that 60% of content is U.S.-made, higher-value activities are still mostly performed abroad</u>. In Tier 1 as well as Tier 2, railcar OEMs[2] and system suppliers, many of which are non-U.S.-owned firms, predominantly keep their higher value activities such as design and engineering in their home countries. They meet Buy America requirements by completing the manufacturing and assembly in the United States, either at permanent facilities or at temporary sites using local subcontractors.

<u>3) The U.S. value chain includes several gaps—specific manufacturing activities that are not typically performed in the United States</u>. These gaps vary among the six target rail types. For example, a high-

[1] Calculation by Michael Renner, Senior Researcher at Worldwatch Institute, based on data from the GovernmentAccountability Office, Federal Transit Administration, and Federal Railroad Administration.
[2] Original equipment manufacturers, or firms at the end of the supply chain that assemble the final product.

speed rail component may currently be manufactured exclusively overseas, while the equivalent component for regional rail is made domestically by several firms. Depending on the rail category, activities often performed outside the United States may include propulsion systems, fabricated trucks,[3] electronic systems, and doors. Often these gap categories require complex machinery and special skills, so companies typically invest in them only in overseas locations where there is a stronger market.

4) Manufacture and assembly of passenger and transit railcars and locomotives comprise an estimated 10,000 to 14,000 U.S. jobs. These include approximately 4,000 employees in Tier 1 and 6,000 - 10,000 employees in Tier 2 who devote at least a portion of their labor to the manufacture and assembly of these vehicles and components.

5) These jobs may have a more positive impact than their numbers suggest. Compared with other job sectors, manufacturing is estimated to have the largest multiplier effect—generating $1.40 of added economic activity for each $1 of direct spending—and creating on average 2.5 additional jobs for each manufacturing job (Hindery et al., 2009).[4] In addition, the majority of relevant manufacturing facilities are in the Midwest and Northeast industrial states, in which the current economic recession has created the severest job losses. There is also a modest degree of overlap between Tier 2 firms and the motor vehicle industry: 24 of the firms we identified, or about 15%, also produce components for motor vehicles. If current trends continue and the passenger and transit rail vehicle market continues to grow, these firms—as well as their Tier 3 suppliers—may welcome the opportunity to supply a market that is growing in the midst of the economic downturn.

6) Growing the U.S. industry will require committing much larger and more consistent U.S. investments to intercity passenger and urban transit rail. Input we received from firms through online surveys, phone interviews, and other contacts consistently emphasized this need for increased, steady demand in order to stabilize the market and expand the relevant U.S. manufacturing base.

7) Several additional measures can help develop the U.S. industry and capture higher value activities in the supply chain. These include improving the accountability and transparency of Buy America and Buy American rules; revisiting U.S. standards and specifications to stabilize the market and bring down costs; increasing government support for research and development (R&D), and adopting a collaborative, orchestrated approach to expanding the supply chain, encouraging innovation, and bringing new technologies all the way through prototyping and commercialization.

[3] Also called "bogies," or the undercarriage assembly incorporating the wheels, suspension, brakes and traction motors. Definition from Wikipedia, http://en.wikipedia.org/wiki/Rail_terminology#B.

[4] At the upper end of this job multiplier, each high-tech manufacturing job is estimated to create 16 associated jobs.

Introduction

Since the 1950s, the United States has invested far more heavily in highways and air transport than in rail transportation. Recently the U.S. Public Interest Group, citing Congressional Budget Office data, calculated that between 1956 and 2006, for every $1 invested in rail, the nation invested $6 in aviation and $16 in highways (U.S. PIRG Education Fund, 2010). There are signs, however, that U.S. priorities are shifting. The 2009 American Recovery and Reinvestment Act (ARRA) provided a total of $17.7 billion for transit (including bus transit) and intercity rail programs combined,[5] including $1.3 billion for Amtrak and $8 billion for new high-speed rail corridors and intercity passenger rail.

While these are small investments compared to those in other countries with well-developed passenger rail systems, they constitute a watershed in the nation's commitment to passenger rail, and they have been presented as a "down payment" on future investments (White House, 2010). Similarly, current proposals for the much-anticipated renewal of the nation's six-year surface transportation bill call for significantly greater commitments to public transit, including rail.

If the United States is to increase its investment in passenger rail and transit rail, several important questions arise: How much of the required "rolling stock"—the passenger locomotives and railcars—will be manufactured in the United States? What gaps in the current U.S. supply chain need to be filled? What are the relevant opportunities for U.S. manufacturing?

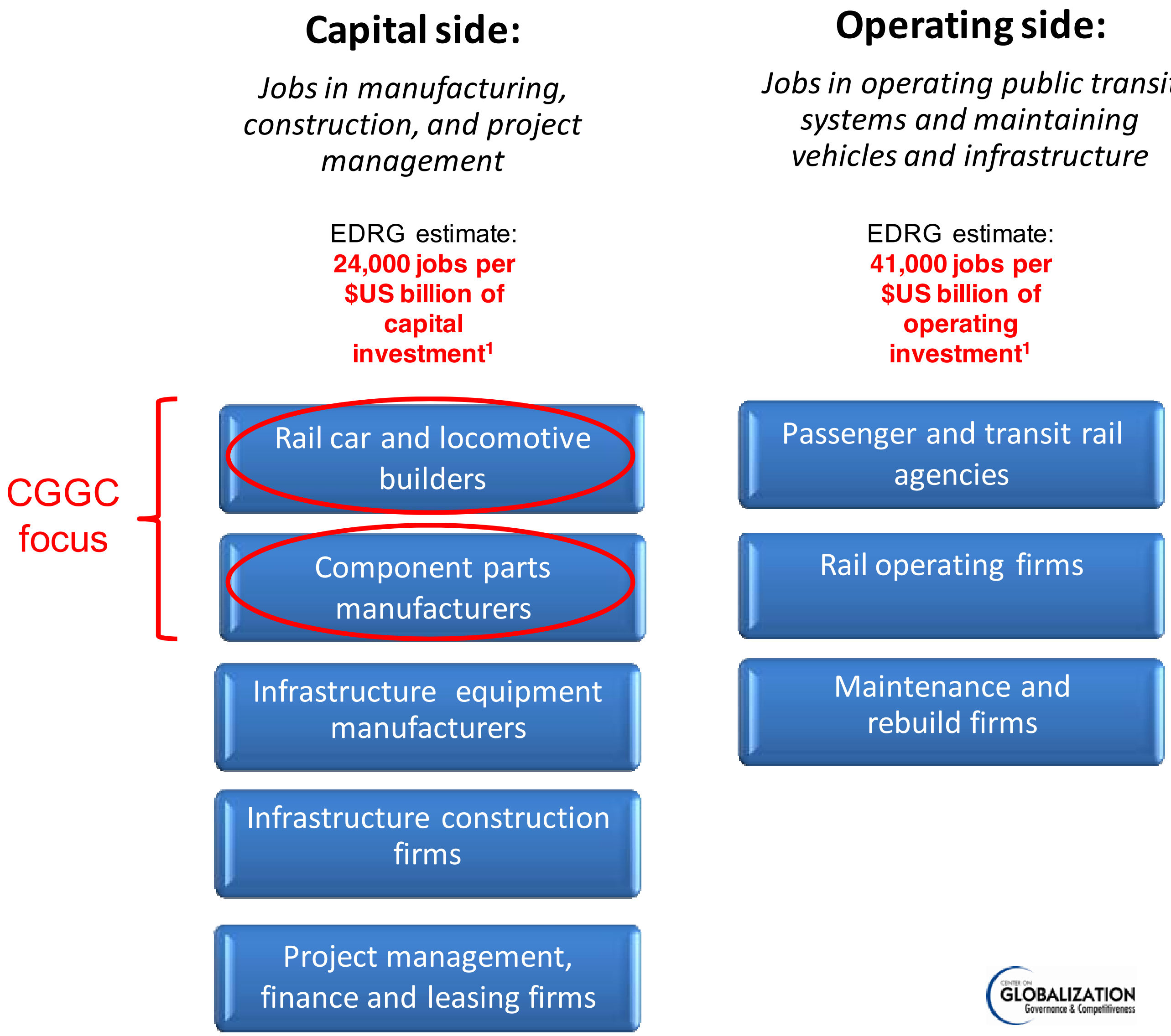
Indeed, the award of high-speed rail grants highlighted the need not only to improve transportation choices but also to create U.S. jobs and revitalize the manufacturing sector. Transportation Secretary Ray LaHood announced in December 2009 that more than 30 rail manufacturers, domestic- and foreign-owned, had committed to establish or expand their U.S. operations if they were chosen by states receiving the new high-speed rail grants (U.S. Federal Railroad Administration, 2009).

This report will map out the U.S. value chain for passenger and transit rail vehicles and identify the nature and extent of the manufacturing that takes place in the United States. We will estimate the number of U.S. manufacturing jobs involved in Tier 1 (rail car and locomotive builders) and Tier 2 (component parts manufacturers). Of course, these manufacturing jobs constitute just one category of jobs in the rail industry, which comprises many other categories supported by investments in public transportation, both on the capital side and the operating side. Previous research conducted on behalf of the American Public Transit Association (APTA) has estimated the number of jobs supported per billion dollars of public investment. On the capital side (jobs in manufacturing, construction, and project management) it is estimated that for every $US billion dollars of capital investment, 24,000 jobs are supported for one year. On the operating side, this figure is estimated at 41,000 jobs. The focus of this study is current manufacturing employment in two categories that fall under the capital side: 1) railcar

[5] Calculation by Michael Renner, Senior Researcher at Worldwatch Institute, based on data from the GovernmentAccountability Office, Federal Transit Administration, and Federal Railroad Administration.

and locomotive builders, and 2) component parts manufacturers (See Figure 1). Several other large categories of rail jobs lie outside the scope of this study, including infrastructure equipment manufacture, infrastructure construction, project management, and additional agencies and firms involved in operation and maintenance of rail systems.

Figure 1. Rail vehicle manufacturing jobs in the broader context of total rail industry jobs



[1]Estimates by Economic Development Research Group. Jobs are defined as "jobs supported for one year."

Source: CGGC; job estimates from (Economic Development Research Group, 2009).

Passenger and transit rail: 6 types

In this report, we address the manufacture of railcars for six types of rail: intercity passenger rail, high-speed rail, regional rail, metro, light rail, and streetcars. We will describe each of the six rail types in Tables 2 and 3 below. First, however, it is useful to understand one of the major differences in the vehicles that characterize each rail type: how it is powered. Each type of rail uses one or more of the following power options, as shown in Table 1.

Diesel-electric. A diesel engine provides mechanical energy to an electric generator, which provides power to traction motors that drive each axle. Traction motors, not the engine, drive the wheels. This is the most common configuration in U.S. intercity passenger rail outside the Northeast Corridor.

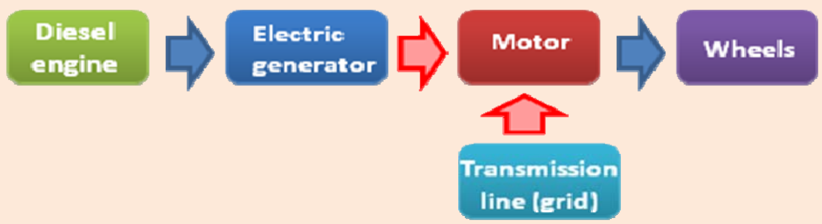
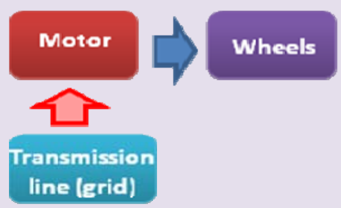
Dual mode. The same diesel-electric configuration described above can be complemented by a power grid connection. This way, on stretches where an overhead wire is available—as in the Northeast Corridor—the train can shut off its diesel engine and instead power its traction motors directly from the grid. The dual mode arrangement is not necessary where electrification is widely available, as it is in Europe and Japan.

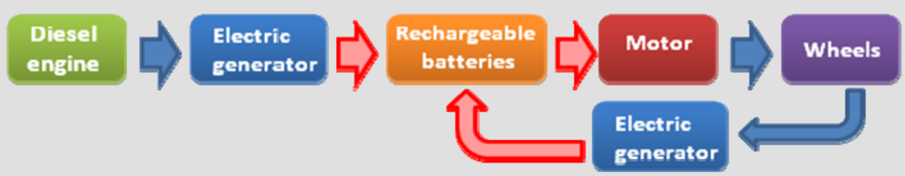
All-electric. A continuous connection to the power grid, either via overhead lines or an electrified third rail, eliminates the need for an engine. This is typical in the urban rail categories (metro, light rail and streetcars). It is also found in intercity passenger rail in Japan and much of Europe.

Hybrid-electric (prototype stage). Leveraging hybrid systems already in use in hybrid buses, a few firms are developing rail applications in which a rechargeable battery is added to store surplus energy derived from the engine and from the wheels during braking. This stored energy can be used to boost available power when needed.

Table 1. Passenger rail and urban transit rail: types of power supply

<table>
<tr><th>Type of Power</th><th>Examples</th></tr>
<tr><td>Diesel electric

</td><td>Nearly all U.S. intercity passenger rail except for the Northeast Corridor</td></tr>
<tr><td>Dual mode

</td><td>U.S. Northeast Corridor</td></tr>
<tr><td>All electric

</td><td>Metros, light rail, streetcars

Intercity passenger rail in Japan and much of Europe</td></tr>
<tr><td>Hybrid-electric (prototype stage)

</td><td>Under development by BAE Systems, General Electric</td></tr>
</table>

Source: CGGC.

Key characteristics of each of the six target rail categories are found below, in Table 2 and Table 3.

Intercity passenger rail. Service links large cities, typically at speeds of 50-110 miles per hour. In the United States, all intercity passenger rail service is offered by Amtrak, operating on track that is shared with the freight rail network. U.S. passenger trains are powered chiefly by diesel electric locomotives. In Europe, right of way is much less frequently shared with freight rail. Most European intercity passenger trains are powered by all electric, or in some cases, electro-diesel (diesel-electric configurations complemented by a connection to the power grid).

High-speed rail (HSR). Service connects cities up to 500 miles apart, with special infrastructure and railcar designs that allow trains to operate at higher speeds. In the United States, currently the only high-speed line is the Acela in the Northeast Corridor, which is designed for speeds up to 150 mph, but because of infrastructure limitations, in fact reaches much lower speeds. Because of long distances between cities and track shared with freight, the U.S. potential for high-speed rail is different from many other countries. Electrification (connection to the grid) is so far only available in the Northeast Corridor. While the U.S. definition of HSR can be as low as 80 mph, the international definition for upgraded lines is above 124 mph (200 km/hr), and for new lines, above 155 mph (250 km/hr).

Regional rail (commuter rail). Service is over short distances connecting a city center to surrounding towns and suburbs. More than 20 regional rail systems now serve 25 major U.S. metropolitan areas. They often use electric multiple units (EMUs)—self-contained combinations of two or more rail cars that have their own electric propulsion. EMUs thus can either be added to or dropped from a train at a given station, according to need. Regional rail can also use diesel multiple units (DMUs), similar to EMUs but with diesel-electric propulsion. On regional rail lines that are not electrified, DMUs offer the flexibility to add or drop train cars at stations on a multi-city route, according to occupancy needs.

Metro (rapid transit). Service is high frequency and for urban, short-distance trips. Trains operate on exclusive right of way and are designed for many passengers to stand as well as sit. Speeds are typically less than 80 mph (130 km/hr). Power supply is electric, using electric multiple units.

Light rail (LRT). Service is for busy urban corridors, connecting major destinations such as downtowns, shopping and campuses. LRT typically uses exclusive right of way, although some systems share streets with car traffic. Trains usually include 1-4 railcars, carrying up to 220 passengers and traveling up to 66 miles per hour (105 km/hr). LRT mostly uses electric multiple units but can use diesel multiple units.

Streetcars (trolleys). Service offers frequent stops in a central urban area, often meant to attract "choice" riders (those who have access to an automobile). Streetcars usually share city streets with car traffic and are thus less expensive to build and operate than higher-speed and higher-capacity rail systems that operate on exclusive right of way. Vehicles are lightweight, typically consisting 3-body cars with capacity of up to 180 passengers. Electricity is most often provided by overhead lines. Unlike other urban rail types, streetcars are typically ordered by city governments, not by transit authorities—although streetcars are part of the federal government's "livable communities" agenda, which qualifies them for federal funding. Often cities invest in streetcars to enhance economic development in a downtown. There are three types of streetcar: heritage cars (replicas), retrofitted cars and modern streetcars (pictured in Table 3).

Table 2. Passenger rail characteristics: intercity, high-speed rail, and regional rail

Passenger Rail Category	Typical context	Right of Way	Capacity	Speed	Power Supply
Intercity passenger rail  (Wilcox, 2008)	Long distance travel linking large cities US: Low frequency of service	US: Shared track with freight	High capacity for seated passengers Comfortable seating	50 – 110 mph (80-180 km/hr)	US: Mostly diesel electric locomotives Europe: Mostly all-electric
High-speed rail  (McCaughrin, 2007)	Connects cities at short, medium and long distances up to 500 miles (800 km)	US: Amtrak Acela shares track with freight & regional rail Europe & Asia: Mostly exclusive right of way	High capacity for seated passengers US: Acela has 304 seats Japan: Shinkansen double-decker has 1,634 seats	US: Can be as low as 80 mph (130 km/h) International* definition: New lines above 155 mph (250 km/hr); Upgraded lines above 124 mph (200 km/hr)	US: In NE corridor only, diesel electric with connection to the grid Japan and Europe: All electric
Regional rail (also known as commuter rail)  Intersystem Concepts, 1999	Short distances from city center to surrounding towns & suburbs Includes service to low-density areas US: More than 20 regional rail systems now serve 25 major metropolitan areas	Shares track with intercity or freight trains	High seating capacity More seating than standing room 60 - 185 seats per car	30 to 125 mph (50 to 200 km/h)	In Europe, mostly uses electric multiple units; can use diesel multiple units or electric locomotives

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*UIC definition (Union International des Chemins de Fer)

Source: CGGC, based on (Federal Railroad Administration, 2009; Parkinson & Fisher, 1996; TGVweb, 2001; Union Internationale des Chemins de Fer, 2008; Wikipedia, 2010).

Table 3. Transit rail characteristics: metro, light rail, and streetcars

Transit Rail Category	Typical context	Right of Way	Capacity	Speed	Power Supply
Metro (also rail rapid transit, subway, underground, or elevated)  Trevor Hart, 2004	High frequency urban rail service High capacity for short-distance trips	Exclusive right of way	Designed for many passengers to stand during short rides Range 3 - 12 cars per train; Max. 150 passengers per train	Less than 80 mph (130 km/hr)	Electric - electric multiple units (EMUs)
Light rail  Totsie14, 2005	Service on busy urban corridors, connecting major destinations such as downtowns, shopping districts and campuses	Usually exclusive right of way; some systems share streets with car traffic	Typically 1 - 4 train cars; Max. 220 passengers Train length 60 - 120 meters	Less than 66 mph (105 km/hr)	Usually uses electric multiple units; can use diesel multiple units
Streetcars (also known as trams, trolleys or on-road light rail)  Doug Beghtel, 2009	Rail service with frequent stops, often meant to attract "choice" riders (those who have access to an automobile) and to enhance economic development	Usually share city streets with car traffic, but may have exclusive right of way	Lightweight vehicles with low capacity; usually 3-body cars. Maximum 180 passengers	Less than 43 mph (70 km/hr)	Electric, usually with catenary (overhead lines)

Source: CGGC, based on (Parkinson & Fisher, 1996; Smatlak, 2010; Victoria Transport Policy Institute, 2010).

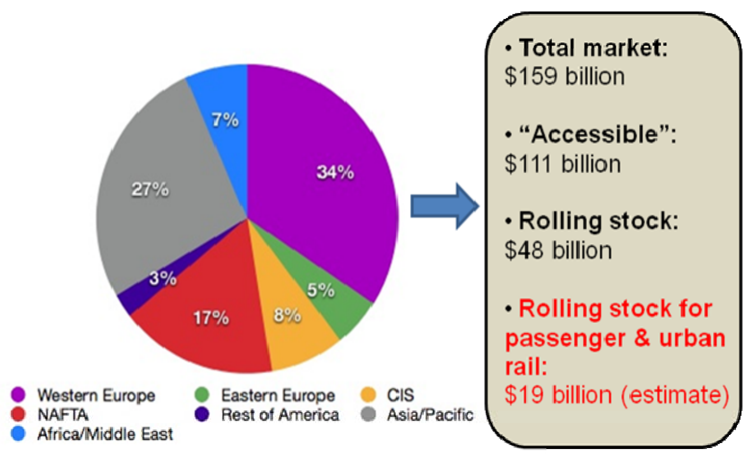
Global market for passenger and transit rail vehicles

Rail vehicles, also called rolling stock, are a subset of the global market for rail equipment, accounting for 30% of total rail equipment by value. Rolling stock is the second largest product segment behind services (43%)—a category that includes maintenance, spare parts and refurbishment for rail vehicles and infrastructure. After services, the next largest segments are infrastructure (18% of total value), and rail control (8%).[6] Rail vehicles for passenger rail and urban rail (as opposed to freight rail) account for an estimated $19 billion, or about 40% of the global market for rolling stock.

The United States is by far the largest rail equipment market in the world.[7] This is thanks to the nation's highly developed freight rail system. In the 1950s, the percentage of U.S. and European freight moved by rail was about equal (approximately 58 percent). By 2000, the share of U.S. freight transported by rail was 38 percent, while in Europe it was only 8 percent (Vassallo & Fagan, 2005). As of 2002, the Americas accounted for roughly one-third of the world's diesel locomotives and freight wagons (U.S. PIRG Education Fund, 2010).

A study conducted for UNIFE, the association of the European rail industry, estimated that in 2005-2007 the total global market for rail equipment was $159 billion (see Figure 2). The market considered "accessible"—meaning open to foreign suppliers—equaled an estimated $111 billion. Looking ahead, UNIFE projects a 2.0 - 2.5% annual growth rate for the world accessible market between 2007-2016. According to *Global Mass Transit Report*, the European rail market is growing below the average, while Asia has become the world's fastest growing market (Global Mass Transit Report, 2009).

Figure 2. Global rail equipment market, by region, 2005-2007



Source: CGGC, based on (Roland Berger & UNIFE, 2008)

[6] Percentages add up to 99% due to rounding.
[7] The next largest single-country markets are China and Russia.

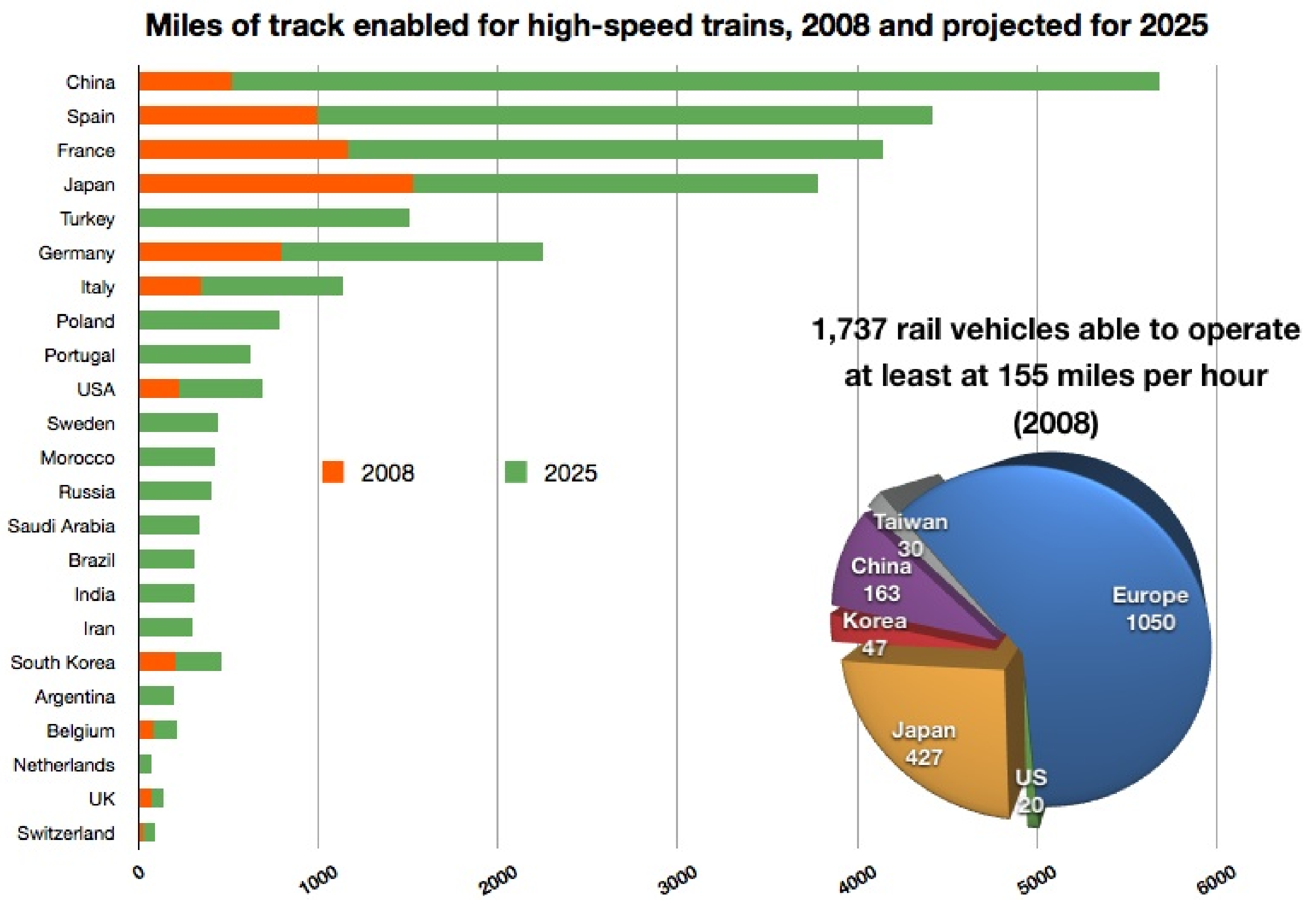
A handful of companies dominate the global rail vehicle industry. In 2005, the total sales of the three largest players—Bombardier (Canada), Alstom (France) and Siemens (Germany)—equaled roughly half of the world's rail vehicle market (Mellier, 2005). However, the total rail equipment market, including infrastructure, rail control and services, is changing rapidly as a result of rail expansion in China. According to one recent analysis, two Chinese companies, China CNR and China South Locomotive and Rolling Stock Industry Group (CSR), have edged out Siemens to become the third and fourth respective top rail equipment firms in the world, shifting Siemens to fifth place. Transmashholding (Russia) is now in sixth place, followed by three U.S. freight rail equipment firms: GE, Trinity Industries, and Electro-Motive Diesel (EMD). Kawasaki (Japan) occupies the number ten spot (Leenen & Briginshaw, 2009).

Several countries' increased investments in high-speed rail will continue to have a dramatic effect on the global rail equipment market. According to China's rail ministry, China is opening 1,200 miles of high-speed rail in 2010, with the goal of linking all provincial capitals with bullet trains. Externally, China is seeking to build high-speed routes in the United States and Brazil, and has already begun construction in Saudi Arabia, Turkey and Venezuela (Bradsher, 2010).

In the United States, however, the high-speed rail segment is notably small. While the recent commitment of $8 billion in stimulus funds to HSR is a significant step, it is negligible compared to plans to develop and expand such systems in Europe and Asia. Because of low levels of investment and the sharing of track with freight rail, HSR in the United States will involve much lower train speeds than those found in Europe and Asia.[8] It will also require very different infrastructure as a result of the nation's longer distances and lack of electrified lines. For these reasons, the U.S. context will likely continue to look quite different from that in other countries. HSR development will likely have an early focus on improving existing infrastructure so that Amtrak's newer passenger trains can reach speeds they were designed for (up to 155 mph). As of 2008, the United States had 20 such HSR vehicles, while Japan had 427, and Europe had 1,050. An international comparison of HSR vehicles and miles of enabled track is shown in Figure 3.

[8] According to the American Association of Railroads (AAR), more than 90 percent of Amtrak service runs on rights-of-way owned by freight railroads (Association of American Railroads, 2010).

Figure 3. International comparison of high-speed rail vehicles and enabled track, 2008



Source: (Milmo, 2009).

U.S. market

The U.S. market for passenger and transit rail is the most open market in the world. While many countries' rail vehicle markets include major domestic-owned OEMs (for instance, Alstom in France, Siemens in Germany, or Talgo in Spain), the U.S. market has had no such players of its own for nearly three decades. The only exceptions are General Electric, EMD (formerly GM-EMD), and Motive Power (Wabtec), three makers of freight locomotives that also serve the passenger rail industry. As a result of the lack of domestic rail car firms, an unusually large number of foreign-owned rail car manufacturers participate in the U.S. market.

Major players

Table 4 shows 20 firms at the Tier 1 OEM level that serve the U.S. market for at least one of the six rail types. Several firms are large players active internationally in most or all categories, even if they serve the U.S. market only in selected ones; these firms include AnsaldoBreda, CAF, Hyundai Rotem, Kawasaki, Kinkisharyo, Nippon Sharyo, and Siemens. One global firm, Bombardier, supplies the U.S. market in all types except streetcars. Alstom, another global player with a footprint in all categories, serves the U.S. market in all the "heavy rail" types (those other than light rail and streetcars).

Seven of the 20 Tier 1 OEMs are U.S. firms. These include the following:

- EMD, GE and Motive Power, each of which make locomotives for intercity and regional rail for U.S. and non-U.S. markets
- Three vintage streetcar firms: Brookville, a freight rail player that rebuilds streetcars; Kasgro Rail, a freight rail company that supplies vintage streetcars, and Gomaco, which makes vintage streetcars
- United Streetcar, a new entrant that makes modern streetcars (discussed in detail on page 46)
- US Railcar Company, a new entrant that plans to make diesel multiple units (DMUs) for regional rail (discussed in detail on page 47).

Table 4. Rail car and locomotive OEMs serving the U.S. market, with international footprint

Builder	Intercity Passenger Rail	High Speed Rail	Regional Rail	Metro Rail	Light Rail	Streetcar
Alstom	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	(non-U.S.)	(non-U.S.)
AnsaldoBreda	(non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	(non-U.S.)
Bombardier	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	(non-U.S.)
Brookville 🇺🇸						[railcar]
CAF USA	(non-U.S.)	(non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	(non-U.S.)
EMD[a] 🇺🇸	(L) (non-U.S.)		(L) (non-U.S.)			
Gomaco 🇺🇸						[railcar]
GE 🇺🇸	(L) (non-U.S.)		(L) (non-U.S.)			
Hyundai Rotem	(non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	(non-U.S.)	(non-U.S.)	
Inekon Trams*						[railcar] (non-U.S.)
Kasgro Rail Corp.[b]						[railcar] (non-U.S.)
Kawasaki	(non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	
Kinkisharyo	(non-U.S.)	(non-U.S.)	(non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	(non-U.S.)
Motive Power 🇺🇸	(L) (non-U.S.)		(L) (non-U.S.)			
Nippon Sharyo	(non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	
Siemens	(non-U.S.)	(non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	[railcar] (non-U.S.)	
Skoda[c]	(non-U.S.)					[railcar] (non-U.S.)
Talgo[d]		[railcar] (non-U.S.)				
United Streetcar 🇺🇸						[railcar]
US Railcar 🇺🇸	[railcar]		[railcar]			

[railcar] Firm serves U.S. railcar market   (L) Firm serves U.S. locomotive market   (non-U.S.) [shaded] Firm serves non-U.S. market

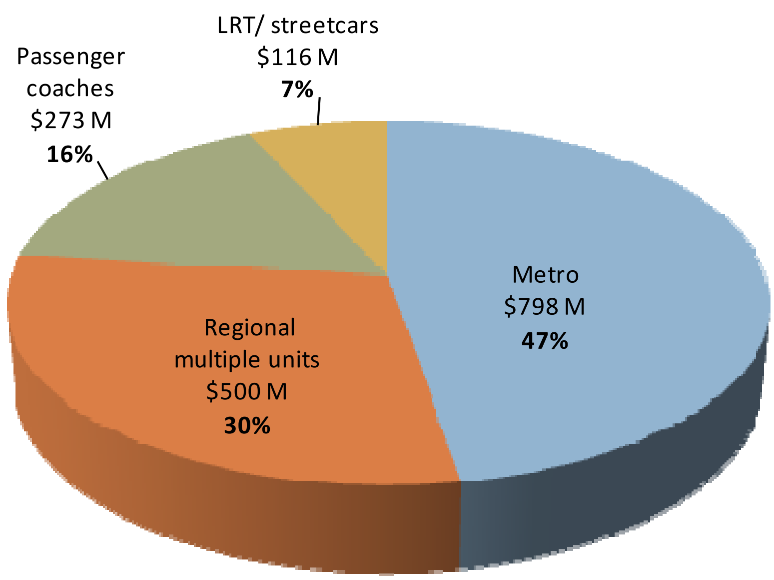
Notes:
[a] Between 1976 and 1981, EMD supplied locomotives to Amtrak that are still part of the active fleet.
[b] Kasgro Rail Corporation, predominantly a freight rail company, supplied vintage streetcars for Galveston, TX.
[c] Skoda Transportation is leasing its streetcar technology to United Streetcar, which is manufacturing streetcars in the United States. Skoda does not have a U.S. manufacturing/assembly location.
[d] Worldwide, Talgo is solely focused on intercity passenger rail with speeds of 79 - 235 mph. Talgo does not yet have a U.S. manufacturing location; however, the company since 1998 has operated a maintenance facility in Seattle, WA, where it maintains trains it built for Amtrak. In 2010 Talgo will open a plant in Milwaukee, WI to build high-speed trainsets (see page 49).

Source: CGGC, based on company websites, interviews and news releases. Image source: (Richtom80, 2007).

Size of market

According to UNIFE estimates, the value of the U.S. rail vehicle market for passenger and transit rail in 2005-2007 was $1.7 billion (UNIFE, 2010). A breakdown of the market is found in Figure 4. Measured by value, the largest segment was metro, at $798 million, accounting for 47% of the total. Next were multiple units for regional rail ($500 million), accounting for 30%, and passenger coaches ($273 million), accounting for 16%. Finally, LRT and streetcars ($116 million) accounted for 7% of the total. New York City constitutes the single largest market, such that the U.S. picture for supply and demand changes significantly based on whether New York is acquiring new cars or rebuilding existing cars (D. Bowen, 2010).

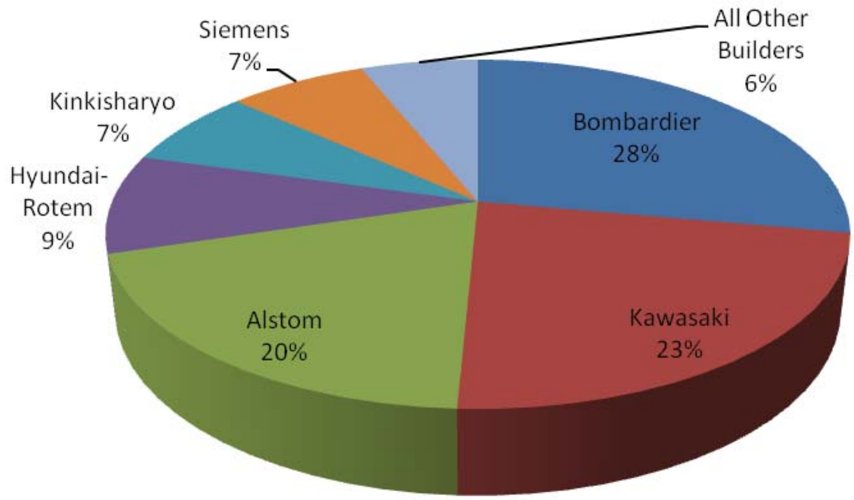
Figure 4. U.S. market for passenger and transit rail vehicles, 2005-2007, by type (total market: $1,687 million)



Source: UNIFE data for 2005-2007.

An approximate picture of the leading firms' U.S. market share is shown in Figure 5. These figures are based on Railway Age Magazine data on the total number of new rail cars produced for regional and urban transit rail categories during the 4-year period ending in 2010—during which the only intercity (Amtrak) activity consisted of rebuilding old railcars. Bombardier (Canada) is the largest supplier, accounting for 28% of the total market for heavy and light rail. Alstom Transport and Kawasaki Railcar each also account for roughly 20% of the U.S. market. Other market leaders include Hyundai-Rotem USA, Kinkisharyo International, LLC, and Siemens.

Figure 5. U.S. market for new railcars for regional, metro, light rail and streetcars



Note: Percentages based on number of new rail cars delivered 2006 - 2009 and undelivered cars in progress as of Jan 1, 2010
Source: Railway Age Magazine data sets from 2007-2010: (D. J. Bowen, 2008; Luczak, 2007; Miller, 2009, 2010)

Table 5 breaks out the U.S. market data for 2006-2009 by rail car type, also highlighting the major role played by rebuilt rail cars. Measured in number of units, the largest new car market in the period was for metro cars (2,231 units). Regional/intercity followed (1,583 new units for regional), then light rail (771 units), and streetcars (32 units).

These market share figures show the following:

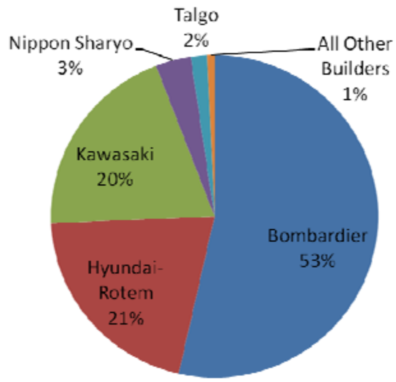
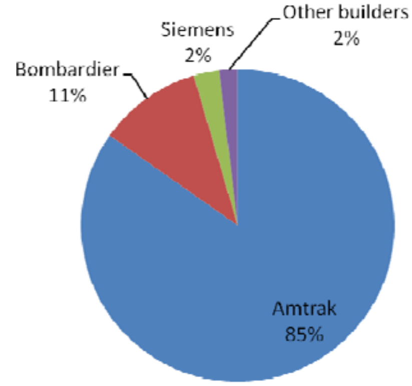
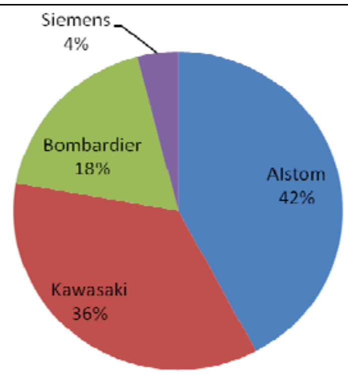
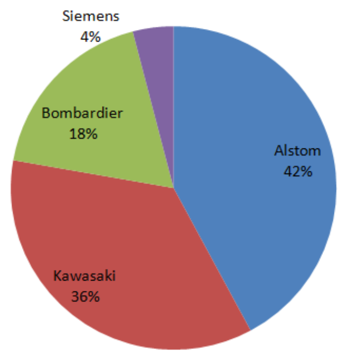
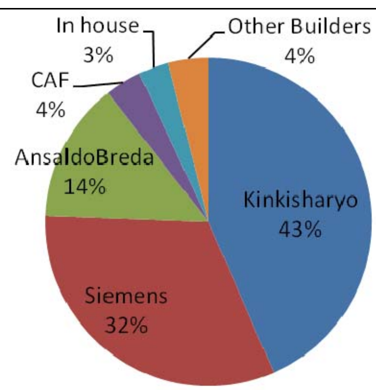
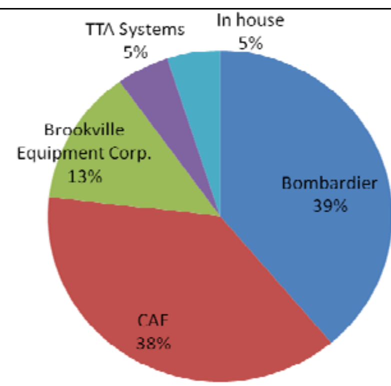
Regional/intercity. Bombardier is the leading supplier of new regional rail cars with approximately 50% of the market, followed by Hyundai-Rotem (21%) and Kawasaki (20%). Bombardier's largest contracts during the period were for commuter cars serving New Jersey Transit and Long Island Rail Road. The rebuild market for regional and intercity cars largely consisted of Amtrak rail cars, primarily done by Amtrak. Bombardier held 11% of this market, more than half of which was work done on behalf of Amtrak.

Metro. Two large firms led the market: Alstom Transport (42%) and Kawasaki Rail Car (36%). In a contract awarded in July 2002, these companies partnered to supply the New York City Transit system with a total of 1,662 metro cars, the largest mass transit contract in the United States (Alstom Transport, 2008).[9] In the target four-year period, Bombardier held 18% of the market. In rebuilding and maintenance, Alstom was the only firm active during the period, although a greater number of metro cars were refurbished in house by the Bay Area Rapid Transit System's rolling stock shop.

[9] Alstom provided 1,002 cars and Kawasaki provided 660 cars (Wochele, 2010).

Light rail and streetcars. Builders of light rail vehicles account for nearly all of the light rail/streetcar market, led by Kinkisharyo (43%), Siemens (32%), and AnsaldoBreda (14%). In streetcars, by contrast, a handful of manufacturers supply fewer than 10 cars each. Several of these streetcar builders are U.S. companies, including Brookville Equipment Corporation and Kasgro Rail (two predominantly freight rail firms), and United Streetcar, discussed in detail on page 46. Bombardier and CAF USA lead the rebuild and maintenance market for light rail vehicles, while Brookville and in-house rebuilds in New Orleans accounted for most streetcar rebuilds.

Table 5. U.S. market share by rail car type, 2006-2009

Car Type	New Cars	Rebuilt Cars
Regional/ Intecity	 **1,583 units**	 **1,560 units**
Metro	 **2,231 units**	 **799 units**
Light Rail and Streetcars	 **803 units**	 **121 units**

Note: Based on number of new and rebuilt cars delivered 2006-2009 and undelivered in progress as of Jan 1, 2010
Source: Railway Age Magazine data sets from 2007-2010: (D. J. Bowen, 2008; Luczak, 2007; Miller, 2009, 2010)

Domestic content requirements

The United States has longstanding legislation on domestic content. Procurements supported by agencies such as the Department of Defense (DOD), Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), and Federal Transit Administration (FTA) have each been subject to such provisions for decades.

In 1978, a "Buy America" provision was added to the federal transportation bill, specifically applying to procurements funded by grants to state and local agencies through the FTA, FHWA, and FRA. This Buy America provision states that final assembly of trains, buses, ferries, and other vehicles purchased with the support of federal funds must occur in the United States. The provision further requires 60% domestic content; in other words, the cost of components manufactured domestically must represent more than 60% of the cost of all components. Waivers from these domestic purchasing requirements can be obtained for the following three reasons (Apollo Alliance, 2010):

1) Preference for the domestic product is "inconsistent with the public interest," a broad category that can include impacts on project outcomes or on domestic markets or firms.

2) The product is not available in the United States in sufficient and reasonable quantity or satisfactory quality.

3) Procuring the product or component domestically would increase project costs by more than 25%.

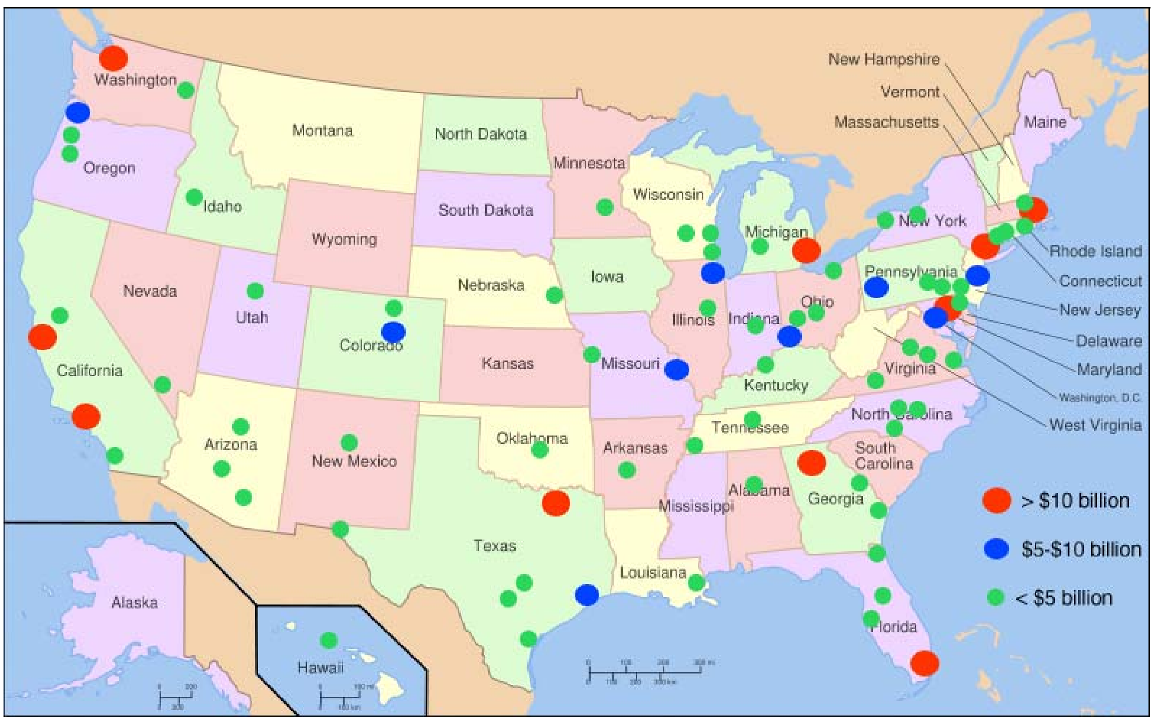
FTA and FHWA-funded projects also require all steel and manufactured products used in infrastructure projects to be 100% U.S.-manufactured, with the same set of permissible waivers. Domestic content requirements for Amtrak vehicles differ slightly from those that apply to other vehicles purchased with federal transportation dollars. Amtrak passenger rail purchases costing more than $1 million must include "substantially" U.S.-made components, which has previously been interpreted to mean that at least 51% of components must be domestically sourced. The domestic content requirements that apply to Amtrak rolling stock also allow for a fourth waiver, if equipment cannot be bought and delivered in the United states within a reasonable time.

In 2009, ARRA reinforced and expanded existing domestic content rules, specifying that they also apply to vehicles purchased with ARRA funds. FTA-funded vehicle purchases will continue to follow the existing Buy America rules described above—requiring final assembly in the United States and 60% U.S.- manufactured content. Amtrak rolling stock will continue to be subject to a similar, though separate set of rules (Foshay, 2010).

Pent-up demand

The U.S. market appears poised for growth. In urban transit rail, industry analysts forecast growth due to a combination of pent-up demand for rail service and a backlog of needed capital investment. According to a recent nationwide analysis of transit agencies' and municipal planning organizations' long-range plans,[10] at least 400 rail, streetcar and bus rapid transit projects are in the planning (see Figure 6). In total, these projects represent over $248 billion of investment in 76 regions in 37 states, including 10 projects worth over $10 billion. The analysis emphasizes, however, that it remains to be seen how much of this demand will be satisfied by adequate funding. Constructing all of these projects at the current rate of federal funding would take an estimated 77 years (Reconnecting America, 2009).

Figure 6. U.S. planned fixed guideway projects, according to local agencies' long-range plans



Source: (Reconnecting America, 2009)

An important aspect of future investment is the need to bring existing systems into a state of good repair. In a recent speech, FTA Administrator Peter M. Rogoff noted that the backlog of deferred maintenance at our seven largest rail operators alone is more that $50 billion. He cited an FTA assessment of all of the nation's public transit assets—including rail, bus and paratransit[11]—which found that fully 29

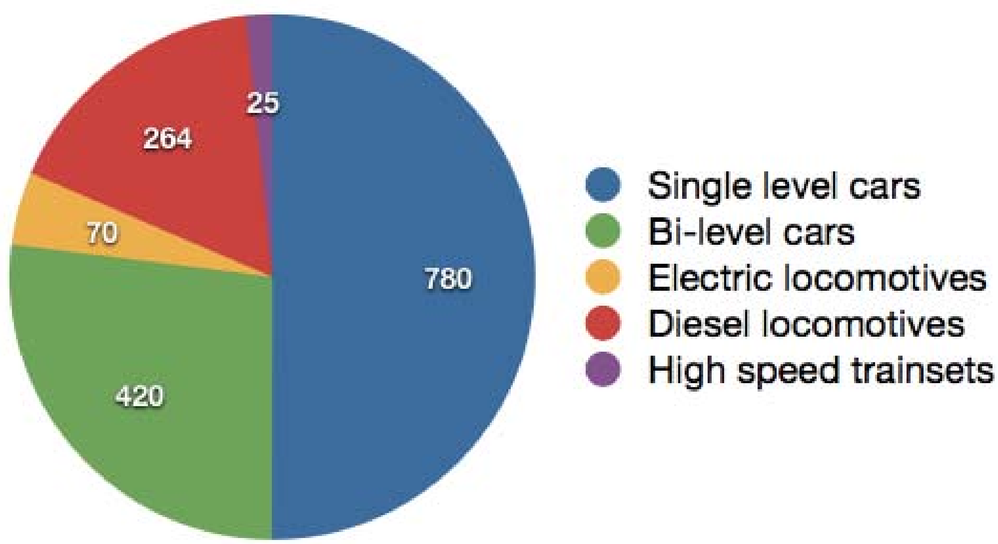
[10] Conducted by Reconnecting America, a project of the Center for Transit-oriented Development. Website: http://www.reconnectingamerica.org/public/about

[11] Individualized transportation service that supplements larger, fixed-route public transit.

percent are in poor or marginal condition. The investments needed to bring all of these 690 separate rail and bus systems to a state of good repair is an estimated $78 billion (Rogoff, 2010).

Similarly, the U.S. intercity passenger rail system is in need of investments that have long been postponed. Amtrak, because of funding constraints, has not ordered new rolling stock since 2001. The average age of Amtrak rolling stock is 25 years, and the fleet includes some railcars that are 60 years old—older than Amtrak itself, because they were purchased used (Uznanski, 2010). Amtrak calculates that, in the next 14 years, it will need to buy 1,200 railcars, 334 locomotives, and 25 high-speed trainsets[12] (see Figure 7). This represents a total investment of $11 billion in 2009 dollars (Amtrak, 2010). More broadly, a 2007 report commissioned by the National Surface Transportation Policy and Revenue Study Commission found that to re-establish the national intercity passenger rail network would require capital investments of an estimated $8.1 billion annually through 2050 (Passenger Rail Working Group, 2007).

Figure 7. Projected Amtrak new rail vehicle needs, 2010-2023 (number of units, by type)



Source: Data from Amtrak Fleet Strategy (Amtrak, 2010)

[12] Indivisible blocks of railcars.

U.S. value chain

Method

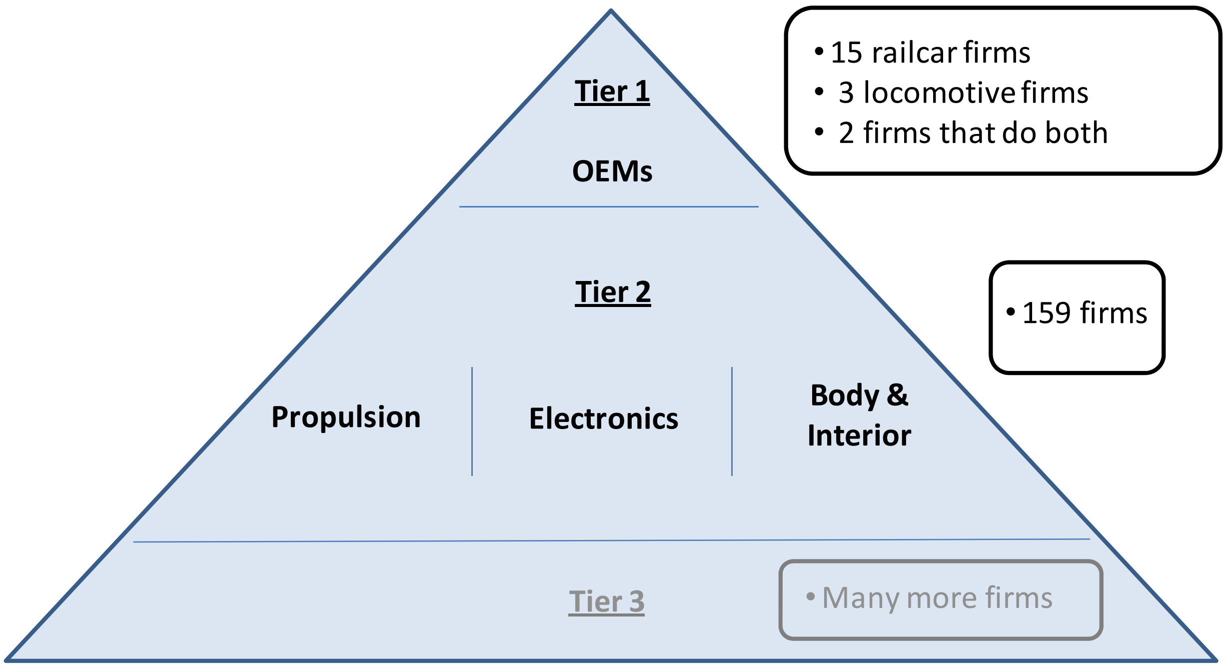
When we began to map out the U.S. value chain, we found that the publicly available North American Industrial System (NAICS) codes did not capture a number of important firms in Tier 2 (suppliers of components and systems to Tier 1 OEMs).[13] In addition, many data sources do not distinguish freight rail firms from the firms involved in the six passenger and transit rail types. To identify as many relevant firms as possible, we filtered a number of company lists for the rail industry from numerous sources including International Railway Journal, Railway Supply Institute, Rail Serve, Jane's Urban Transport Systems and Metro Magazine. Selected firms were also willing to share their supplier lists. These sources combined to yield a semi-final list of 159 Tier 2 firms, to which we sent a brief online survey. Twenty-eight firms responded to the survey, and we reached nearly all of the remaining firms through follow-up phone calls. In addition, we conducted in-depth phone interviews with 11 Tier 1 OEMs. The following description of the value chain is based on the data gathered through these direct contacts with firms.

How the industry is organized

Figure 8 depicts the general structure of the industry as a pyramid. Tier 1 consists of large and small OEM firms that, at a minimum, provide the shell (body), design, and final assembly of railcars or locomotives. Focusing on firms that have U.S. manufacturing locations, our research identified 15 railcar builders, three locomotive builders, and two firms that do both: Bombardier and Alstom. Tier 2 is divided into three systems: propulsion, electronics, and body and interior. We identified 153 firms of all sizes at the Tier 2 level, including some OEMs that provide their own propulsion systems and in some cases supply them to other OEMs. According to our survey of firms, on average, each Tier 2 firm supplies seven to eight Tier 1 OEMs, with one-third of firms reporting that they supply more than 10 OEMs. Tier 3, not covered in this study, includes firms that supply parts and materials to companies in the top two tiers.

[13] Of the final count of 159 firms we found in Tier 2, only 26 were initially identified by rail-related NAICS codes.

Figure 8. Organization of U.S. manufacture of vehicles for passenger and transit rail

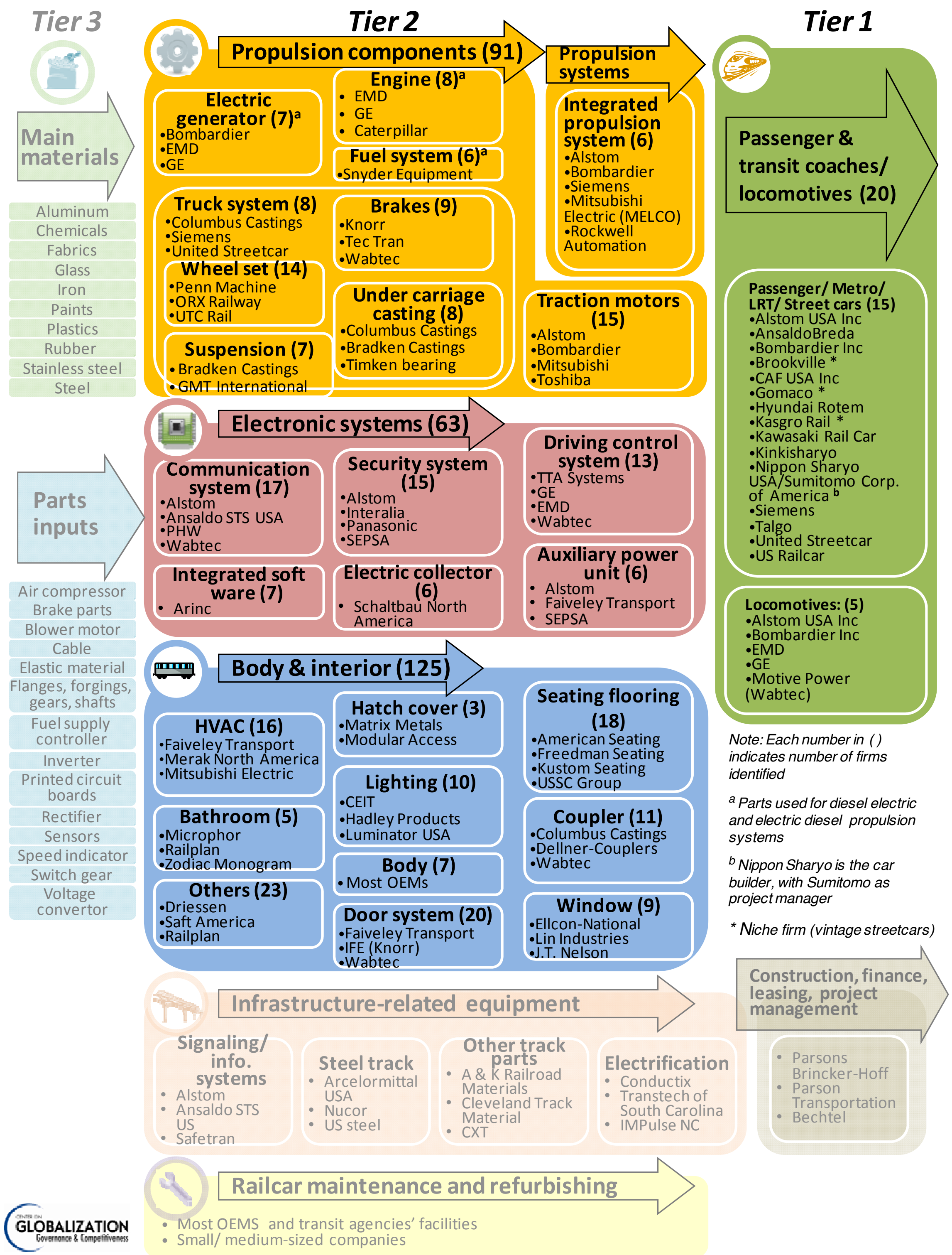


Source: CGGC, based on industry surveys and interviews and (Esposito & Passaro).

The value chain for the U.S. passenger and transit rail equipment industry is found in Figure 9. Beginning with the first column on the left, Tier 3 (not covered in detail in this study) includes main materials (aluminum, iron, steel, etc.) and input parts such as air compressors and brake parts. Tier 2 consists of the firms that provide the main systems that go into rail vehicles: propulsion, electronics, and the body and interior. Each of these systems includes several major components, for which the leading firms are listed.[14] Tier 1 consists of the OEMs that build railcar and locomotive shells and perform final assembly. After each category heading, the figure in parentheses indicates the number of firms we have identified that have relevant manufacturing facilities in the United States. Other categories that are also considered Tier 2 rail equipment, but not covered at the firm level in this study, are infrastructure-related equipment (including steel track, signaling, electrification) and railcar service, maintenance and refurbishing (performed by most Tier 1 OEMs as well as transit agencies and small to medium-sized firms).

[14] A full list of all identified firms appears in Table 7 on page 31. Details on each company are found in Table 8 (page 34) and Table 9 (page 37).

Figure 9. U.S. value chain for passenger and transit rail vehicles



Source: CGGC, based on company websites and industry interviews.

General characteristics

Vehicles for passenger and transit rail constitute a small industry in the United States. The majority of the U.S. employment is in the subcontractor firms, not the OEMs. Tier 1 and Tier 2 OEMs and component system suppliers, many of which are non-US-owned, predominantly keep their higher value activities such as design and engineering in their home countries, or at least in locations near much larger markets. Table 6 provides estimates of the share of each railcar component system in total value added.

Table 6. Passenger and transit railcars: share of value added

	Share of total value added
Railcar shell*	10%
Final assembly	10%
Propulsion	15-20%
Electronics	10-15%
Body & interior	40-50%

*Built in the United Sates by four of the 10 well-established OEMs (Alstom, Bombardier, Kawasaki, Siemens) and United Streetcar. US Railcar also plans to build its shells in the United States.

Source: CGGC, based on company interviews.

Most components produced for passenger and transit rail vehicles are not compatible with those produced for freight vehicles. However, at the Tier 2 level, several manufacturers do supply selected components to the freight rail industry as well as to passenger and transit rail. Examples include Wabco and Knorr (NY Airbrake),[15] two firms that produce brake systems for each market. Similarly, three freight locomotive builders—EMD, GE and Motive Power—also supply locomotives to the passenger rail market, both in the United States and abroad. Recently, an additional freight rail equipment manufacturer, Arkansas-based American Railcar (ARI), entered a joint venture with new passenger rail entrant US Railcar to make diesel multiple units for regional rail. In undertaking this joint venture, ARI is responding to the current recession-related downturn in the freight rail industry, in which thousands of locomotives are idle and new orders have plummeted. The company intends to use this opportunity to help fill its plant capacity in a low-risk way (Pracht, 2010).

[15] NY Airbrake is 100% owned by Knorr. NY Airbrake is the freight side of the business; Knorr is the passenger side.

Tier 1

Railcars and locomotives are built near the market they serve. However, because the U.S. market for passenger and transit rail has been smaller than in other countries, several Tier 1 OEMs build their railcar shells for the U.S. market outside the United States—near larger markets in Europe or Japan, or in Brazil or Mexico. Four leading Tier 1 OEMS build their car shells in U.S. locations with U.S. labor: Alstom (metro shells built in Hornell, NY), Bombardier (metro cars built in Plattsburgh, NY), Kawasaki (metro car shells built in Lincoln, NE) and Siemens (LRT shells built in Sacramento, CA). Two new U.S. firms are either already building car shells domestically or plan to do so: United Streetcar (streetcar shells built in Clackamas, OR), and US Railcar (DMU shells planned to be built in northeast Arkansas).

OEMs tend to keep the high-value roles—such as design, engineering, and systems integration—near their home headquarters, or at least near the largest markets they serve. In the case of a small U.S. rail market dominated by foreign-owned companies, this means offshore. Typically, a non-U.S. builder only keeps a small engineering staff in the United States and instead relies on consultants, making the role of consulting firms much larger in the U.S. industry than is typical in Europe or Asia. A large OEM may manage its own network of hundreds of suppliers worldwide, although local suppliers are usually preferred when available. Sourcing will consist of a different mix of U.S. and non-U.S. firms for each project a car builder undertakes. Firms find it much more efficient and reliable to source whole systems rather than seek items component by component.

Vertical integration—or the degree to which firms perform activities in house—varies widely, with transit rail OEMs typically providing more than just the shell and assembly. Several OEMs build their own propulsion systems at sites in the United States (Alstom, Bombardier, and Siemens), sometimes supplying them to other OEMs. For example, Alstom builds propulsion systems in Hornell, NY and sells them to Kawasaki. Alstom also builds traction motors, auxiliary power units, and signaling. Firms performing fewer manufacturing activities in house at U.S. locations include CAF (Spain) and AnsaldoBreda (Italy).

Of the Tier 1 firms we interviewed, Alstom was the only major car builder that reported using union labor in a permanent facility—the International Association of Machinists (IAMAW) in Hornell, NY and the International Brotherhood of Electrical Workers (IBEW) in Rochester, NY. A recent entrant, United Streetcar, uses union labor (Ironworkers and IBEW) in its two plants, in Clackamas, OR and Vancouver, WA. Among OEMs that assemble railcars in temporary facilities with subcontract workers, however, it is not unusual to use union labor. For example, Talgo used union labor in Seattle several years ago to build Amtrak trains for the Northwest Corridor. Talgo also has been working with Amtrak's union workforce since 1998 in its Seattle, WA maintenance facility, where the company maintains five Talgo trainsets that run in the Pacific Northwest Corridor's "Cascades Service."

Tier 2

Most of the 159 firms we identified in Tier 2 have their global headquarters in the United States. In fact, only 22 firms had non-U.S. headquarters, primarily in France and Germany. These firms are similar to the Tier 1 OEMs in that they typically do the engineering in their home countries and, to meet Buy America requirements, perform lower-value manufacturing in the United States. As with Tier 1, some Tier 2 firms meet Buy America rules by establishing permanent U.S. facilities, while others make temporary use of local subcontractors. The remaining 135 companies we identified are U.S. firms. Of the 28 firms that responded to our survey, 14 reported that their top-selling relevant product was 91-100% U.S. content. Only one firm reported domestic content under 20%.

Many Tier 2 firms are diverse, serving more than just the rail industry. For example, castings firms, important in the propulsion category, typically work on a variety of projects for various industries, with passenger and transit rail representing only a small portion of their sales. Some firms have an advantage in that they have large business segments in other industries that can carry them regardless of whether they win rail-related contracts. For example, we identified 24 Tier 2 firms that also supply the motor vehicle industry, including five companies involved in propulsion, five in electronics, and 14 in the body and interior segment.

Of the 28 Tier 2 firms that responded to our survey, 8 firms (29%) reported using union labor.

Full list of identified suppliers with U.S. manufacturing locations

Table 7 provides the full list of firms we identified that use domestic manufacturing facilities to supply the rolling stock market for passenger and urban transit rail. The 159 Tier 2 firms are listed by system category, including propulsion (91 firms), electronic systems (64 firms), and body & interior (125 firms).[16] One U.S. company, Wilmerding, PA-based Wabtec, appears in several subcategories under each of these system areas. Also included in Tier 2 are a handful of freight rail firms such as National Railway Equipment and Motive Equipment, which devote a very small portion of their business to supplying parts to passenger railcar manufacturers. In Tier 1, the 20 firms we identified include 10 rail car builders, three heritage streetcar niche firms (Brookville, Gomaco, and Kasgro), two new U.S. firms (US Railcar and United Streetcar) and five locomotive firms (Alstom, Bombardier, EMD, GE, and Motive Power).

[16] We identified 159 “unique” firms. Because a number of firms participate in more than one category, the three category totals add up to 299.

Table 7. Suppliers with U.S. manufacturing locations for passenger and transit rail vehicles

Tier 1 (20)

Rail car OEMs -Coach/Metro/ LRT/ Street cars (15)		Locomotives (5)
Alstom USA AnsaldoBreda Bombardier Brookville[1] CAF USA Gomaco[1] Hyundai Rotem Kasgro Rail[1]	Kawasaki Rail Car Kinkisharyo Nippon Sharyo USA/Sumitomo Siemens Talgo United Streetcar US Railcar [1] Niche firm (vintage streetcars)	Alstom USA Bombardier EMD GE Transportation Motive Power (subsidiary of Wabtec)

Tier 2: Propulsion systems (91)

Traction motor (15)	Electric generator (7)	Suspension (7)	Wheel set (14)	Truck system (8)
ABB Alstom Baldor Electric* Bombardier CAM Innovation Dayton-Phoenix Group EMD Emerson Electric** Flanders Electric GE Transportation Matrix Metals National Railway* Saminco Siemens Toshiba International	Bombardier Dayton-Phoenix Group EMD GE Transportation Mitsubishi Electric PHW Wabtec **Undercarriage casting (8)** ACME Industries Bradken Steel Castings Eagle Bridge Huebner Matrix Metals OmniCast Tri-State Machining Wabtec	A. Stucki Amsted Industries (formerly Asf-Keystone)* Bradken Steel Castings GMT International KONI N. America (ITT Group) Matrix Metals ZF Sachs Automotive of America	Amsted Industries* Greenbrier* ImageMap Knorr Brake Modular Access National Railway* ORX Railway Penn Machine Progressive rail R&W Standard Steel TTA Systems UTC Rail	Amsted Industries (Asf-Keystone)* Bradken Steel Castings Columbus Steel Castings Hyundai Rotem Kawasaki Rail Car Nippon Sharyo USA OmniCast Siemens United Streetcar **Engine (8)** Cummins Caterpillar EMD Fairbanks Morse Engine GE Transportation Hatch & Kirk [a] National Railway* Wabtec
Fuel system (6) Cummins EMD Modular Access Paragon Products Snyder Equipment Wabtec	**Integrated propulsion system (6)[b]** Alstom USA Bombardier Mitsubishi Electric Siemens Toshiba International Rockwell Automation[c]	**Brake parts (7)** Fluid Connector Inter Swiss Matrix Metals Products, Inc. Standard Car Truck Tec Tran Westcode	**Brake system (3)** Knorr Brake (New York Air Brake) Tec Tran Wabco (subsidiary of Wabtec)	**Sanding system (2)** IBEG Knorr Brake

Tier 2: Electronic systems (63)

Auxiliary power unit (6)	Driving control system (12)	Communication (17)	Integrated soft ware (7)	Security system/event recorder (15)
Advanced Transit Manufacturing Alstom USA Bombardier Dayton-Phoenix Group SEPSA North America Toshiba International **Electric collector (6)** Knorr Brake MAC Products Schaltbau North America Schunk Transtech of South Carolina Wabtec	Bombardier Converteam Eaton Elcon EMD GE Transportation KONI N. America (ITT Group) Kontron AG Matrix Metals Siemens TTA Systems VPS Control Systems	Advanced Transit Mfg Alstom USA Ansaldo STS USA Bombardier Interalia Linovation Luminator USA Orthstar Enterprises** Panasonic Transportation[d] PHW Rail Development Group Safetran Systems Schaltbau North America Trackmobile* Twinco Mfg VECOM USA Wabtec	Alstom USA Alcatel Arinic Ansaldo STS USA GE Transportation Innovative Scheduling* Wabtec	Alstom USA Cisco Interalia KLD Labs Kontron AG Kps Na Lat-Lon* Panasonic Transportation Safety Vision* SEPSA North America Security with Advanced Technology, Inc. VECOM USA Verint Systems Wabtec Wi-Tronix

Tier 2: Body & Interior (125)				
Door system (20) Advanced Structure Advanced Transit Mfg Albatross-Sepsa Cattco Dynamic Metals Ellcon-National Faiveley Greenbrier* Hudson Machine Works IFE North America J.T. Nelson Knorr Brake Lin Industries Milufab (Division of Wabtec) Mitsubishi Electric Stanrail* Vapor Bus International (Subsidiary of Wabtec) Vapor Stone Rail Systems (Subsidiary of Wabtec) Wabtec Westcode	**HVAC (16)** Advanced Transit Mfg Dayton-Phoenix Group Merak North America Mitsubishi Electric (MELCO) Motive Equipment* National Railway Equipment* Niagara Cooler** Northwest Rail Electric Rtr Technologies Sigma Coachair Group Stone Safety Thermo King Transitair Vapor Stone Rail Systems (Subsidiary of Wabtec) Wabtec Westcode	**Body (10)** Alstom Alcoa Bombardier Hudson Machine Works Kawasaki Rail Car Siemens Stanrail* Super Steel Products United Streetcar US Railcar **Coupler, articulation system (11)** A&A Manufacturing Advanced Transit Manufacturing Amsted Industries (formerly Asf-Keystone)* Columbus Steel Castings Dellner-Couplers Faiveley Transport GE Transportation Greenbrier* Hubner Manufacturing Hudson Machine Works Wabtec	**Seating, flooring (18)** Able Manufacturing and Assembly ADTrans American Seating Bentech Cattco Dynamic Metals Freedman Seating Kuston Seating Unlimited Lantal Textiles Milwaukee Composites Mohawk RCA Rubber Rocky Mountain Composites Seats Inc Testori Interiors TTA Systems USSC Group	**Others (23)**[e] Amsted Industries (formerly Asf-Keystone)* Bentech Driessen Filnor Faiveley Transport Griffith Rubber Mills Maverick Technical Systems Modular Access Systems Railplan Saft America Snyder Equipment Visual Marking Systems **Wiper**: AM Equipment Sprague Devices Wexco Industries **Horn, bells:** Buell Air Horns Graham-White Manufacturing Harrington Signal Matrix Metals Micro Precision North Pacific Communications VECOM USA Wabtec
Lighting (10) Amglo Kemlite Laboratories** Dialight Hadley Products Ledtronics Luminator USA Julian A. McDermott* Matrix Railway Meister Rail Development Group Trans-Lite	**Window (9)** Dynamic Metals Ellcon-National Faiveley Transport Hehr International J.T. Nelson Lin Industries North American Specialty Glass Young Windows Wabtec	**Bathroom (5)** INCA Gold Products Microphor (Subsidiary of Wabtec) Motive Equipment* Railplan Zodiac Monogram	**Hatch cover (3)** Matrix Metals Modular Access Systems Stanrail*	

Notes: * Company mainly sells freight products; participates far less in transit/passenger rail.
** Company has U.S. manufacturing location for rail-related products, but possibly only for freight.
[a] Hatch & Kirk produces injector parts only.
[b] Four companies, Alstom, Bombardier, Mitsubishi Electric and Siemens, are main suppliers of integrated propulsion systems manufactured in the United States, including traction motors, inverters, and train control systems
[c] Rockwell Automation will supply propulsion systems to United Streetcar (Brown, 2010).
[d] Panasonic Transportation Systems supplies communication systems to Alstom and Kawasaki (EMS Technologies, 2005).
[e] Others include fare collection systems, batteries, racks, bumpers, rail chocks, catering equipment, portable water systems, horns, bells, wiper systems, interior fittings.

Source: CGGC, based on industry surveys, company interviews, selected firms' supplier lists, and company websites.

Firm-level data on Tier 1 and Tier 2 firms

Tier 1

Firm-level data we collected on companies in Tier 1 yield the following characteristics:

- Rail car builders range from large global companies such as Bombardier (whose transportation unit employs 33,800 people and has sales of $10 billion) to small niche firms that rebuild heritage streetcars, such as Kasgro (predominantly a freight rail firm, with 159 total company employees and $2.6 million in annual sales).
- The most vertically integrated companies are Alstom, Bombardier, Siemens, and the three locomotive firms, providing many systems and components in addition to the car shell.
- In the U.S. market for all six passenger and transit rail categories combined, the three leading railcar builders are Bombardier, Kawasaki, and Alstom, each with roughly 25% market share over the most recent 4-year period.
- Market share for the three locomotive firms (GE Transportation, EMD and Motive Power) is difficult to calculate from the recent 4-year period, since Amtrak has not ordered a new locomotive since 2001; however, Motive Power has consistently supplied locomotives to the regional rail market (commuter rail).
- In high-speed rail, a total of 25 trainsets currently operating in the United States are built to run at 125 mph. These include Amtrak's 20 Acela trainsets built by a Bombardier-Alstom consortium, which operate in the Northeast Corridor, and five Cascades Service trainsets built by Talgo, which operate in the Pacific Northwest Corridor.
- There are four car builders in the state of New York: Alstom in Hornell, Bombardier in Plattsburgh, CAF in El Mira, and Kawasaki in Yonkers.

Full entries for all identified Tier 1 firms appear in Table 8 on the following pages.

Table 8. Tier 1 firms with U.S. manufacturing and assembly locations: firm-level data

Company Name	U.S. HQ	Relevant U.S. manufacturing locations	Total company employees	Total company sales ($ mil)	% of U.S. market for pass/ transit rail [a]	Major components provided by company in addition to shell
Passenger railcar coaches /Metro/ LRT/ Street cars						
Alstom Transport (France)	Hornell, NY	Kearny, NJ Hornell, NY +Mare Island, CA +Naperville, IL Rochester, NY +Wilmington, DE	26,500	7,400	21	Auxiliary power units; Communication system; Integrated propulsion system; Integrated soft ware; Locomotives; Security systems; Shell; Traction motor
Ansaldobreda (Italy)	Pittsburg, CA	Pittsburg, CA	2,410	566	2	Integrated propulsion system
Bombardier Transportation (Canada)	Washington, DC	+Camden, NJ +Kanona, NY Plattsburgh, NY Pittsburgh, PA	33,800	10,009	28	Auxiliary power units; Body; Communication system; Driving control system; Electric generator; Integrated propulsion system; Locomotives; Traction motor
Brookville Equipment	Brookville, PA	Brookville, PA	190	63	N/A	None
CAF USA (Spain)	Washington, DC	Elmira Heights, NY	2,000	995	1	None
Gomaco Trolley	Ida Grove, IA	Ida Grove, IA	N/A	N/A	N/A	None
Hyundai Rotem (South Korea)	Philadelphia, PA	Philadelphia, PA	3,910	1,808	9	Truck systems
Kasgro Rail	New Castle, PA	New Castle, PA	160	2.6	N/A	None
Kawasaki Rail Car (Japan)	Yonkers, NY	Yonkers, NY Lincoln, NE	30,563	15,080	23	Shell; Truck system
Kinkisharyo International (Japan)	Westwood, MA	Palm Harbor, FL	946	716	7	None
Nippon Sharyo USA (Japan)	Arlington Heights, IL	San Francisco, CA Cleveland, OH Milwaukee, WI [b]	1,738	904	1	Truck system
Siemens (Germany)	Sacramento, CA	Sacramento, CA Alpharetta, GA Norwood, OH	405,000	106,000	7	Body; Communication system; Driving control system; Integrated propulsion system; Traction motor; Truck system
Talgo (Spain)	Seattle, WA	Milwaukee, WI [c] +Seattle, WA	1,000	433	1	None
United Streetcar	Clackamas, OR	Clackamas, OR Vancouver, WA	N/A	N/A	<1	Truck system

Company Name	U.S. HQ	Relevant U.S. manufacturing locations	Total company employees	Total company sales ($ mil)	% of U.S. market for pass/ transit rail [a]	Components provided by company in addition to shell
US Railcar	Columbus, OH	Marmaduke, AR Paragould, AR	N/A	N/A	<1	None
Locomotives						
Electro-Motive Diesel Inc	La Grange, IL	La Grange, IL	4,500	N/A	N/A	Driving control system; Electric generator; Engine; Fuel systems; Traction motor
GE Transportation	Erie, PA	Erie, PA Grove City, PA	100,000	4,500	N/A	Communication system; Coupler; Driving control system; Electric generator; Engine; Integrated soft ware; Traction motor
Motive Power (Wabtec)	Boise, ID	Boise, ID	730	N/A	N/A	Brake system; Driving control system; Traction motor

* Also supplies the motor vehicle industry

+Rebuild and maintenance facility

[a] Based on Railway Age Magazine data for new passenger and transit rail cars delivered 2006-2009 and undelivered in progress as of Jan 1, 2010 *(D. J. Bowen, 2008; Luczak, 2007; Miller, 2009, 2010)*

[b] Rented facilities from other firms

[c] Plans to establish a plant to assemble high speed trains

Source: CGGC, based on company websites, industry surveys and interviews, and Dun & Bradstreet Selectory database.

Tier 2

Firm-level data we collected on companies in Tier 2 yield the following characteristics:

- Manufacturers of electro-mechanical parts, such as motors, generators, engines and integrated propulsion systems, are mostly large railcar or locomotive builders, such as Alstom, Bombardier, Siemens, GE, EMD, and Motive Power (Wabtec). Also active in this category are several large power technology firms, including ABB, Baldor Electric Company, Mitsubishi Electric, Siemens and Toshiba. Products for rail rolling stock represent only a small share of these companies' total sales.

- Brake systems are supplied by three firms, Knorr Brake, Tec Tran and Wabtec. Several additional firms provide brake parts, including Matrix Metals, Standard Car Truck, and Westcode.

- Manufacturers of castings, including those for wheel sets, suspension and sanding systems, are often small companies with fewer than 100 employees. The main manufacturers of integrated truck systems are selected Tier 1 railcar OEMs and a few medium to large steel casting companies, including Bradken Steel Castings (2,800 U.S. employees and $720 million in total sales) and Columbus Steel Castings (750 U.S. employees and $6 million in total sales). For these companies, rail products often represent less than 20% of company sales.

- Electronic systems are dominated by large international companies such as Alstom and Bombardier, which do much of their sourcing elsewhere. However, several small domestic firms with 20-160 employees each supply selected products, including Dayton-Phoenix (Dayton, OH), TTA Systems (Hornell, NY), Advanced Transit Manufacturing (Canisteo, NY), Transtech of South Carolina (Piedmont, SC) and PHW (Pittsburgh, PA). Relevant rail products tend to represent a large share of these companies' total sales, often more than 80%.

- The body & interior segment includes a number of small U.S. firms with fewer than l00 employees. Major seating companies such as American Seating, Freedman Seating, Kustom Seating, Seats Inc. and USSC Group are medium-sized companies with 300 to 1,000 employees. For most seating and flooring companies, the rail market tends to account for less than 20% of sales. For the identified firms involved in HVAC manufacturing, sales from rail products often represent more than 90% of sales.

Full entries for all identified Tier 2 firms appear in Table 9 on the following pages.

Table 9. Tier 2 firms with U.S. manufacturing and assembly locations: firm-level data

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
A&A Manufacturing	New Berlin	WI	New Berlin	WI	N/A	N/A	N/A	Coupler
A. Stucki	Pittsburgh	PA	Newport	NC	50	N/A	N/A	Suspension
ABB (Switzerland)	Stamford	CT	N/A	N/A	(120,000)	34,910	N/A	Traction motor
Able Manufacturing and Assembly*	Joplin	MO	Joplin Pittsburg	MO KS	600	N/A	N/A	Seating, flooring
ACME Industries	Elk Grove Village	IL	Elk Grove Village	IL	130	18	N/A	Undercarriage casting
ADTrans	Mansfield	OH	Mansfield	OH	N/A	N/A	N/A	Seating, flooring
Advanced Structure	Deer Park	NY	Escondido Deer Park	CA NY	100	N/A	Significant part of business	Door systems
Advanced Transit Manufacturing	Canisteo	NY	Canisteo	NY	35	N/A	50%	Auxiliary power units; Communications systems; Coupler; Door systems; HVAC
Sepsa NA (Spain)	Schenectady	NY	Schenectady	NY	45	40	N/A	Auxiliary power units; Door systems; Security systems
Alcatel-Lucent USA Inc (France)	New Providence	NJ	N/A	N/A	N/A (77,000)	22,149	N/A	Integrated soft ware
Alcoa*	Atlanta	GA	N/A	N/A	N/A	26,901	Very low	Body
AM Equipment	Jefferson	OR	Jefferson	OR	21 - 50	N/A	N/A	Wiper
American Seating*	Grand Rapids	MI	Grand Rapids	MI	500	119	Less than 20%	Seating, flooring
Amsted Industries	Chicago	IL	Camp Hill	PA	5,000 to 9,999	500-1000	Most business is for freight	Coupler; Truck system; Suspension; Wheel sets
Ansaldo STS USA (Italy)	Pittsburgh	PA	Pittsburgh Hamilton Batesburg	PA NJ SC	N/A (4,350)	1,680	N/A	Communications systems; Security systems
Arinc	Annapolis	MD	Annapolis Marina Del Rey	MD CA	3,200	919	5%	Integrated soft ware
Baldor Electric	Fort Smith	AR	Fort Smith	AR	7,000	1,955	Less than 0.5%	Traction motor
Bentech	Philadelphia	PA	Philadelphia Youngstown	PA OH	30	5	N/A	Seating, flooring and Others
Bradken Steel Casting	Kansas City	MS	Kansas City Atchison Davenport	MS KS IA	2,800	7,205	1 - 10%	Suspension; Truck system; Undercarriage casting
Buell Air Horns	Lyons	IL	Lyons	IL	6	0.7	20%	Horn, bells
CAM Innovation Inc	Hanover	PA	Hanover	PA	20	6	N/A	Traction motor
Caterpillar Inc*	Peoria	IL	Chicago Mojave	IL CA	N/A (93,813)	32,396	N/A	Engine
Cattco	Cattaraugus	NY	Cattaraugus	NY	N/A	N/A	N/A	Door systems; Seating, flooring

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
Cisco	San Jose	CA	San Jose	CA	N/A	36,000	N/A	Security systems
Columbus Steel Castings Co	Columbus	OH	Columbus	OH	750	52	N/A	Truck system and Coupler
Converteam Inc. (France)	Pittsburgh	PA	Pittsburgh	PA	3,500	N/A	N/A	Driving control systems
Cummins Inc*	Columbus	IN	Rocky Mount	NC	39,800	14,342	N/A	Engine and Fuel systems
			Seymour	IN				
			Jamestown	NY				
Dayton-Phoenix Group Inc	Dayton	OH	Dayton	OH	21-50	N/A	91 - 100%	Auxiliary Power Units; Brake parts; Electric generator; HVAC; Radiator Cooling Fans
			Montmorenci	IN				
Dellner Couplers Group	Charlotte	NC	Charlotte	NC	20	2.8	N/A	Coupler
Dialight	Farmingdale	NJ	Farmingdale	NJ	1,214	1,222	N/A	Lighting
Driessen (Netherlands)	Garden Grove	CA	Garden Grove	CA	200 (10,534)	26 (U.S. Sales)	N/A	Catering equipments
Dynamic Metals	Louisville	KY	Louisville	KY	30	5	91 - 100%	Door systems; Seating, flooring; Windows
Eagle Bridge Machine & Tool	Eagle Bridge	NY	Eagle Bridge	NY	35	4.2	N/A	Undercarriage castings
Eaton*	Columbus	OH	Eden Prairie	MN	74,970	15,376	Small amount	Driving control systems
			Greenwood	SC				
			Spencer	IA				
			Shawnee	OK				
Elcon	Minooka	IL	Minooka	IL	1 to 4	1	N/A	Driving control systems
Ellcon National Inc.	Greenville	SC	Greenville	SC	304	N/A	N/A	Door systems and Windows
Fairbanks Morse Engine	Beloit	WI	Beloit	WI	1,000-4,999	500 -1000	1-10%	Engine
Faiveley Transport (France)	Greenville	SC	Greenville	SC	N/A	20,381	N/A	Couplers; Door systems; Interior fittings; Windows
Filnor	Alliance	OH	Alliance	OH	70	3	50%	Switching systems
Flanders Electric	Evansville	IN	Casper	WY	319	50 - 100	N/A	Traction motor
			Evansville	IN				
			Lakeland	FL				
Fluid Connector	Portland	OR	Meridian	ID	107	288	N/A	Brake parts
			Portland	OR				
Freedman Seating*	Chicago	IL	Chicago	IL	300	20-50	1-10%	Seating, flooring
GMT International Co (Germany)	Villa Rica	GA	Villa Rica	GA	21-50	N/A	31-40%	Suspension
Graham-White Manufacturing Co	Salem	VA	Roanoke	VA	255	34	#N/A	Horns, bells
			Carson City	NV				
			Shreveport	LA				
			Salem	VA				
Greenbrier	Lake Oswego	OR	Chicago Heights	IL	3,693	1,018	Most business is	Coupler; Door systems; Wheel sets

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
			San Bernardino	CA			for freight	
Griffith Rubber Mills	Portland	OR	Portland Eugene Conway	OR OR AR	300	24	N/A	Others
Hadley Products Corp*	Grandville	MI	Grandville Elkhart	MI IN	150	32	N/A	Lighting
Harrington Signal	Moline	IL	Moline	IL	N/A	N/A	N/A	Horns, bells
Hatch & Kirk Inc	Seattle	WA	Seattle	WA	N/A	N/A	N/A	Engine
Hehr International Inc	Los Angeles	CA	Newton Los Angeles Plymouth Fort Worth Pomona Chesaning	KS CA IN TX CA MI	1,000	N/A	N/A	Windows
Hubner* (Germany)	Mount pleasant	SC	Mount pleasant	SC	53	6	81-90%	Articulation systems
Hudson Machine Works, Inc	Brewster	NY	Brewster	NY	110	16	60%	Door systems
IBEG (Germany)	Marietta	GA	Marietta	GA	N/A	1	N/A	Sanding systems
IFE (subsidiary of Knorr) (Austria)	Westminster	MD	Westminster	MD	7	N/A	N/A	Door systems
ImageMap (Changed name to Mermec Inc.)	Columbia	SC	Columbia	SC	30	4	N/A	Wheel sets
Inca Gold Products LLC	Gardena	CA	Gardena	CA	3	1	1-10%	Bathroom
Innovative Scheduling	Gainesville	FL	Gainesville	FL	20-25	N/A	Most business is for freight	Integrated soft ware
Inter Swiss LTD	Chicago	IL	Chicago	IL	N/A	N/A	N/A	Brake parts
Interalia (Canada)	Eden Prairie	MI	Eden Prairie	MI	N/A (110)	25	N/A	Communications systems; Security systems
J.T. Nelson Co	Louisville	KY	Louisville	KY	N/A	N/A	N/A	Windows
Julian A. McDermott	Ridgewood	NY	Ridgewood	NY	50	N/A	Most business is for freight	Lighting
KLD Labs	Huntington Station	NY	Huntington Station	NY	42	4	100%	Security systems
Knorr Brake Corp (Germany)	Westminster	MD	Westminster	MD	1001-5000 (10,763)	4,105	91-100%	Brake systems; Door systems; Electric collector; Sanding systems; Wheel sets
Koni North America	Hebron	KY	N/A	N/A	N/A	N/A	N/A	Suspension
Kontron AG (Germany)	Poway	CA	Poway	CA	163 (925)	637	N/A	Driving control systems and Security systems
Kps Na (Japan)	Elmsford	NY	Elmsford	NY	35	26	N/A	Security systems

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
Kustom Seating Unlimited, Inc	Bellwood	IL	Bellwood	IL	101-1000	N/A	81-90%	Seating, flooring
Lantal Textiles*	Wilmington	NC	Wilmington	NC	58	N/A	20%	Seating, flooring
Lat-Lon*	Denver	CO	Denver	CO	12	5	98% of sales are in rail, but none in passenger, though that may soon change	Security systems
Ledtronics*	Torrance	CA	Torrance	CA	130	13	N/A	Lighting
Lin Industries, Inc.	Farmingdale	NY	Farmingdale	NY	7	16	N/A	Door systems and Windows
Linovation	Ronkonkoma	NY	Ronkonkoma	NY	N/A	N/A	N/A	Communications systems
Luminator USA*	Plano	TX	Plano	TX	190	N/A	N/A	Communication systems and Lighting
MAC Products Inc	Kearny	NJ	Kearny	NJ	125	17	31-40%	Electric collector
Matrix Metals LLC	Keokuk	IA	Keokuk	IA	550	N/A	N/A	Brake parts; Driving control systems; Hatch covers; Horns, bells; Traction motor; Suspension; Undercarriage casting
Matrix Railway	West Babylon	NY	West Babylon	NY	9	10	N/A	Lighting
Maverick Technical Systems	Longview	TX	Gladewater	TX	6	1	1-10%	Motor drives and spray wash systems
Meister	Oldsmar	FL	Oldsmar	FL	10	6	100%	Lighting
Merak North America (Subsidiary of Knorr-Bremse)	Albany	NY	Albany	NY	80	15	N/A	HVAC
Micro Precision Inc	South Windham	CT	South Windham	CT	20 to 49	N/A	N/A	Horn, bells
Microphor (Wabtec)	Willits	CA	Willits	CA	75	80	N/A	Bathroom
Milwaukee Composites	Oak Creek	WI	Oak Creek	WI	30	31	N/A	Seating, flooring
Mitsubishi Electric* (Japan)	Cypress	CA	Pittsburgh	PA	101-1000	24,688	11-20%	Auxiliary power unit; Door systems, Driving control system; Electronic communication system; Electric collector; Electric generator; HVAC; integrated propulsion system; Traction motors[a]

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
Modular Access Systems	Columbia	SC	Ottawa Lake	MI	1-20	N/A	N/A	Fuel systems; Hatch covers; Rail chocks; Wheel sets
Mohawk Industries Inc	Calhoun	GA	Lockbourne	OH	27,400	5,344	N/A	Seating, flooring
Motive Equipment	Milwaukee	WI	Milwaukee	WI	40	4	99%, but most business is for freight	HVAC
National Railway Equipment Co.	Mount Vernon	IL	Silvis	IL	750	N/A	91-100%, but most business is for freight	Overall parts supplier for freight. CGGC interview identified that they are ready to supply for transit/passenger use.
North American Specialty Glass	Trumbauersville	PA	Mount Vernon	IL	51-100	N/A	51-60%	Windows
			Gilman	IL				
			Dixmoor	IL				
			Yorkville	IL				
			Paducah	KY				
			Mount Pleasant	TN				
			Waycross	GA				
			Milwaukee	WI				
			Trumbauersville	PA				
North Pacific Communications	Camas	WA	Camas	WA	N/A	N/A	N/A	Horns, bells
Northwest Rail Electric Inc	Portland	OR	Portland	OR	25	3	91-100%	HVAC
Omnicast	Norton Shores	MI	Norton Shores	MI	N/A	N/A	N/A	Truck system and Undercarriage casting
ORX railway	Tipton	PA	Tipton	PA	N/A	N/A	N/A	Truck system and Wheel sets
Panasonic Corporation of North America (Japan)	Secaucus	NJ	N/A	N/A	N/A (292,250)	77,205	N/A	Communications systems and Security systems
Paragon Products	El Dorado Hills	CA	El Dorado Hills	CA	30	7	N/A	Fuel systems
Penn Machine Company	Johnstown	PA	Blairsville	PA	94	37	N/A	Wheel sets
PHW	East Pittsburgh	PA	East Pittsburgh	PA	50	4.1	100%	Communication systems and Electric generator
Products Inc	Des Moines	IA	Des Moines	IA	N/A	N/A	N/A	Brake parts
Progressive rail	Lakeville	MN	Lakeville	MN	64	25	N/A	Wheel sets
R&W Machine	Bedford Park	IL	Bloomington	MN	57	7.5	N/A	Wheel sets
			Bedford Park	IL				
Rail Development Group	Rochester	NY	Rochester	NY	15	1.6	N/A	Communications systems and Light
Railplan	Baltimore	MD	Baltimore	MD	30	3	N/A	Bathroom; Catering equipment; Complete Interior Systems
RCA Rubber	Akron	OH	Akron	OH	170	128	N/A	Seating, flooring

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
Rocky Mountain Composites	Spanish Fork	UT	Spanish Fork	UT	130	140	N/A	Seating, flooring
Rockwell Automation	Milwaukee	WI	N/A	N/A	19,000	4,332	N/A	Propulsion systems
Rtr Technologies	Stockbridge	MA	Canaan	CT	20	3.5	100%	HVAC
Safetran Systems - subsidiary of Dimetronic Signals- (Spain)	Louisville	KY	Louisville Marion Rancho Cucamonga	KY KY CA	N/A	N/A	N/A	Communication system; signaling equipment (infrastructure)
Safety Vision	Houston	TX	Houston	TX	100	N/A	Small amount	Security systems
Saft America Inc* (France)	Valdosta	GA	Valdosta	GA	N/A	84	N/A	Battery
Saminco Inc	Fort Myers	FL	Fort Myers	FL	100-120	N/A	15%	Traction motor
Schaltbau North America (Germany)	Huntington	NY	Huntington	NY	N/A (1600)	359	N/A	Communications systems; Electric collector
Schunk Intec Inc (Germany)	Raleigh	NC	Raleigh	NC	60	N/A	N/A	Electric collector
Seats Inc.	Reedsburg	WI	Reedsburg	WI	101-1000	N/A	1-10%	Seating, flooring
Security With Advanced Technology, Inc. (formerly A4S Security, Inc.)	Loveland	CO	Loveland	CO	N/A	N/A	N/A	Security systems
Sigma Coachair Group (Australia)	Germantown	WI	Germantown	WI	21-50 (261)	66	91-100%	HVAC
Snyder Equipment Co.	Nixa	MO	Nixa	MO	51-100	N/A	81-90%	Fuel systems and Potable water systems
Sprague Devices, Inc*	Michigan City	IN	Wheatland Michigan City	MO IN	50	N/A	N/A	Wiper
Standard Car Truck Co Inc	Park Ridge	IL	Chillicothe	OH	N/A	N/A	N/A	Brake parts
Standard Steel	Burnham	PA	Pittsburgh Bensenville Park Ridge Burnham	PA IL IL PA	2,450	N/A	N/A	Wheel sets
Stanrail	Gary	IN	Gary	IN	60	11	90%, mostly for freight	Door systems
Stone Safety	Madison	CT	Madison	CT	N/A	N/A	N/A	HVAC
Super Steel Products Corp	Milwaukee	WI	Milwaukee	WI	840	79	50%	Body
Tec Tran	Burlington	NC	Burlington	NC	N/A	N/A	N/A	Brake parts; brake systems

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
Testori Interiors Inc	Hornell	NY	Hornell	NY	30	N/A	N/A	Seating, flooring
Thermo King Corp*	Minneapolis	MN	Minneapolis	MN	550	N/A	N/A	HVAC
Timken	Canton	OH	Louisville Hastings Canton	GA NE OH	24,755	56,637	N/A	Truck parts
Toshiba International Corporation (Japan)	Houston	TX	Houston	TX	850 (199,456)	72,534	N/A	Auxiliary power units; Converters; Integrated propulsion systems; Traction motors[b]
Trans-Lite*	Milford	CT	Milford	CT	70	9	N/A	Lighting
Transitair Inc	Hornell	NY	Hornell	NY	N/A	N/A	N/A	HVAC
Transtech of South Carolina	Piedmont	SC	Piedmont	SC	45	8	50%	Electric collector
Tri-State Machining	Friendsville	MD	Friendsville	MD	20	20	N/A	Undercarriage casting
TTA Systems	Hornell	NY	Hornell	NY	160	21	N/A	Driving control systems; seating, flooring; Wheel sets
Twinco Mfg	Hauppauge	NY	Hauppauge	NY	35	6	85%	Communication systems
USSC Group*	Exton	PA	Exton	PA	101-1000	N/A	1-10%	Fire Suppression and Seating, flooring
UTC Rail Inc	Morton	PA	Morton	PA	40	7	N/A	Wheel sets
Vapor Bus International* (Subsidiary of Wabtec)	Buffalo Grove	IL	Buffalo Grove	IL	180	N/A	N/A	Door systems
Vapor Stone Rail Systems (Subsidiary of Wabtec)	Plattsburgh	NY	Plattsburgh	NY	60	N/A	N/A	Door systems and HVAC
VECOM USA	Tampa	FL	Tampa	FL	6	2	N/A	Communications systems; Horns, bells; Security systems
Verint Systems	Melville	NY	N/A	N/A	1,200	250	N/A	Security systems
Visual Marking Systems	Twinsburg	OH	Twinsburg	OH	100	N/A	30%	Labels
Vps Control Systems, Inc.	Hoosick	NY	Hoosick	NY	11	1	31-40%	Driving control systems
Wabco* (Wabtec group)	Piscataway	NJ	Piscataway	NJ	N/A	28	N/A	Brake systems

Company Name	U.S. headquarters		Relevant U.S. manufacturing locations		U.S. employees or (global employees)	Total company sales ($ mil)	% of company sales from rail products	Relevant components manufactured at company's U.S. locations
Wabtec Corp	Wilmerding	PA	Elmsford	NY	7,295	15,747	N/A	Bathroom; Brake systems; Communication systems; Coupler, articulation systems; Door system; Driving control systems; Engine; Electric generator; Electric collector; Electronic security system; Fuel supply system; HVAC; Horn, bells; Integrated soft ware; Undercarriage castings; Window
Westcode Inc	Galesburg	IL	Spartanburg Laurinburg Germantown Wilmerding Chicago Cedar Rapids Warren Los Angeles Willits Boise Kansas City Columbia Johnson City Greensburg Plattsburg Galesburg	SC NC MD PA IL IA OH CA CA ID MO SC TN PA NY IL	101-1000	19	91-100%	Brake parts; Door systems; HVAC
WEXCO Industries	Pine Brook	NJ	Philadelphia Binghamton Pine Brook	PA NY NJ	20	2.5-5	N/A	Wiper
Wi-Tronix	Bolingbrook	IL	Bolingbrook,	IL	14	2	N/A	Security systems
Young Windows*	Conshohocken	PA	Conshohocken	PA	60	99	N/A	Windows
ZF Sachs Automotive of America	Northville	MI	Pittsburgh	PA	150	54	N/A	Suspension
Zodiac Monogram	Carson	CA	Carson	CA	N/A	N/A	N/A	Bathroom

* Also supplies the motor vehicle industry. [a] Only electric generators and propulsion equipment are made in United States. Others are made in Japan. [b] Toshiba's HVAC is made in Japan.

Source: CGGC, based on company websites, industry surveys and interviews, and Dun & Bradstreet Selectory database.

Gaps in the U.S. value chain

In our interviews with companies, we sought to identify areas in the value chain where specific manufacturing activities are not currently performed in the United States. In general, Buy America requirements ensure that much of the manufacturing, and all of the final assembly, occurs domestically. However, in a few cases, waivers are available because a given component is only available from suppliers that manufacture it overseas. These gaps vary among the six target rail types. For example, a high-speed rail component or system may currently be manufactured exclusively overseas, while its counterpart for regional rail is manufactured domestically by several firms. Specific findings include the following:

Car shells. Four of the 10 well-established railcar OEMs active in the U.S. market build their car shells in U.S. locations with U.S. labor: Alstom (metro shells built in Hornell, NY), Bombardier (metro cars built in Plattsburgh, NY), Kawasaki (metro car shells built in Lincoln, NE) and Siemens (LRT shells built in Sacramento, CA). Two new U.S. firms are either already building car shells domestically or plan to do so: United Streetcar (streetcar shells built in Clackamas, OR), and US Railcar (DMU shells planned to be built in northeast Arkansas). All of these shells currently being manufactured in the United States (or, in the case of US Railcar, intended to be manufactured in the near future) are for transit or commuter cars. Body shells for high-speed rail, by contrast, are lighter, usually made of aluminum, and require specific aluminum welding expertise not currently available domestically. This expertise likely will have to be imported until the U.S. workforce is prepared with the necessary skills (Friend, 2010).

Propulsion systems. In the transit rail categories (metro, light rail, and streetcars), integrated propulsion systems are built in the United States with U.S. labor by three of the 10 well-established railcar OEMs—Alstom, Bombardier, Siemens—as well as a Tier 2 firm, Mitsubishi Electric (MELCO). Other railcar OEMs either use systems supplied by these or other providers, or use their own systems but manufacture them abroad. In modern streetcars (a category in which, until recently, there was no U.S.-manufactured propulsion system available), a new entrant is Milwaukee, Wisconsin-based Rockwell Automation. Rockwell recently partnered with Clackamas, Oregon-based United Streetcar to develop new propulsion systems. United Streetcar will use the Rockwell systems to replace the ones it formerly had to import from the Czech Republic (see page 46).

Brake systems. Three firms supply integrated brake systems to the U.S. passenger rail market: Knorr Brake (subsidiary of Knorr-Bremse Group, a German firm), Tec Tran, and Wabtec. While this does not constitute a gap in the U.S. value chain—since these systems are manufactured in the United States with U.S. labor—it is notable that this important system is supplied by such a small number of firms. One factor that makes it difficult to get into the U.S. brake market is that U.S. standards are very different from those in Europe and Japan, thus requiring firms to make extensive adaptations.

Fabricated trucks. Also called "bogies," or the undercarriage assembly incorporating the wheels, suspension, brakes and traction motors.[17] Fabricated trucks are used in high-speed rail, metro, light rail, and streetcars. They require complex equipment and special skills, so companies typically invest in this capability only where there is a strong market, which is often overseas. Two notable exceptions are Siemens, which recently started building truck frames in Sacramento, CA, and United Streetcar, which is building its bogie systems in Clackamas, OR. Otherwise, most fabricated trucks for the U.S. market come from Europe and Japan. Cast trucks, in contrast, are much heavier (weighing some 8,000 pounds) and are still used in certain commuter trains. They are generally made domestically.

Electronic systems. Most electronic systems are sourced elsewhere. With a few exceptions such as driving control systems (provided by several U.S. firms), electronics are typically supplied from Asia or through large European firms' overseas operations.

Doors. Doors were mentioned in company interviews as a gap in the U.S. supply chain for high-speed rail. For other rail types, many firms have U.S. manufacturing locations for doors and door systems. Major players include Faiveley, IFE, and Vapor Bus International (a subsidiary of Wilmerding, PA-based Wabtech), a leader in the North American transit bus industry.

New U.S. entrants

After having no domestic railcar builders for decades, the United States produced two new railcar companies in 2007 and 2009. United Streetcar, founded in 2007, is the first and only U.S.-based modern streetcar manufacturer. A wholly owned subsidiary of Oregon Iron Works—a fabrication and manufacturing company in operation since 1944—United Streetcar offers expertise with metals and welding that enable it to build the car shells and much of the undercarriage in its facilities in Clackamas, Oregon (Brown, 2010). The company unveiled its first U.S.-made streetcar, for Portland, Oregon, in July 2009. It is now building 13 additional streetcars, six for Portland and seven for Tucson, Arizona.

UNITED STREETCAR

Product: Modern streetcars

Founded: 2007

Parent: Subsidiary of Oregon Iron Works

Headquarters: Clackamas, OR

Clients: Portland, OR and Tucson, AZ

Market niche: First and only U.S.-based modern streetcar manufacturer. Now producing cars with 70% U.S. content, soon to increase to 90%

For its first prototype car, United Streetcar signed a technology transfer agreement with Skoda, a Czech railcar firm. The company is now working on newly re-designed cars that will have more advanced technology and more U.S. components. With help from a $2.4 million federal grant, United Streetcar

[17] Definition of truck from Wikipedia, http://en.wikipedia.org/wiki/Rail_terminology#B.

has partnered with Rockwell Automation to develop new U.S.-made propulsion systems. This will increase the U.S. content of United Streetcars' products from the current 70% to 90% (Brown, 2010).

Such high U.S.-content makes these streetcars appealing to city governments, who are the primary purchasers of streetcars and show a clear preference for domestic and local supply chains. United Streetcar is well-positioned to compete with international firms for federally funded projects. According to Buy America rules, now that United Streetcar offers a U.S.-manufactured alternative, transit agencies receiving federal grants to support the purchase of streetcars will no longer qualify for a Buy America waiver on a given project unless the cost of this U.S.-made option is 25% greater.

A second firm, US Railcar Company, was formed in June 2009 with the objective of manufacturing diesel multiple units (DMUs) for intercity and regional rail (see description of DMUs on page 9). US Railcar Company is a joint venture between Value Recovery Group (doing business as Ohio Railcar Group) and American Railcar Industries (ARI), two firms that acquired the assets of the former Colorado Railcar Manufacturing Company (CRM) in 2009. The company plans to manufacture DMUs prototyped by CRM in a demonstration project in Florida in 2002. They are currently the only DMUs fully compliant with FRA regulations for passenger safety (Bloomberg.com, 2010).[18]

US Railcar Company

Product: Diesel multiple units (DMUs)

Founded: 2009

Parent: Joint venture between Value Recovery Group (d.b.a. Ohio Railcar Group, LLC) and ARI DMU, LLC (a subsidiary of American Railcar Industries, Inc.)

Headquarters: Columbus, OH

Market niche: World's only manufacturer of FRA-compliant intercity and commuter DMUs

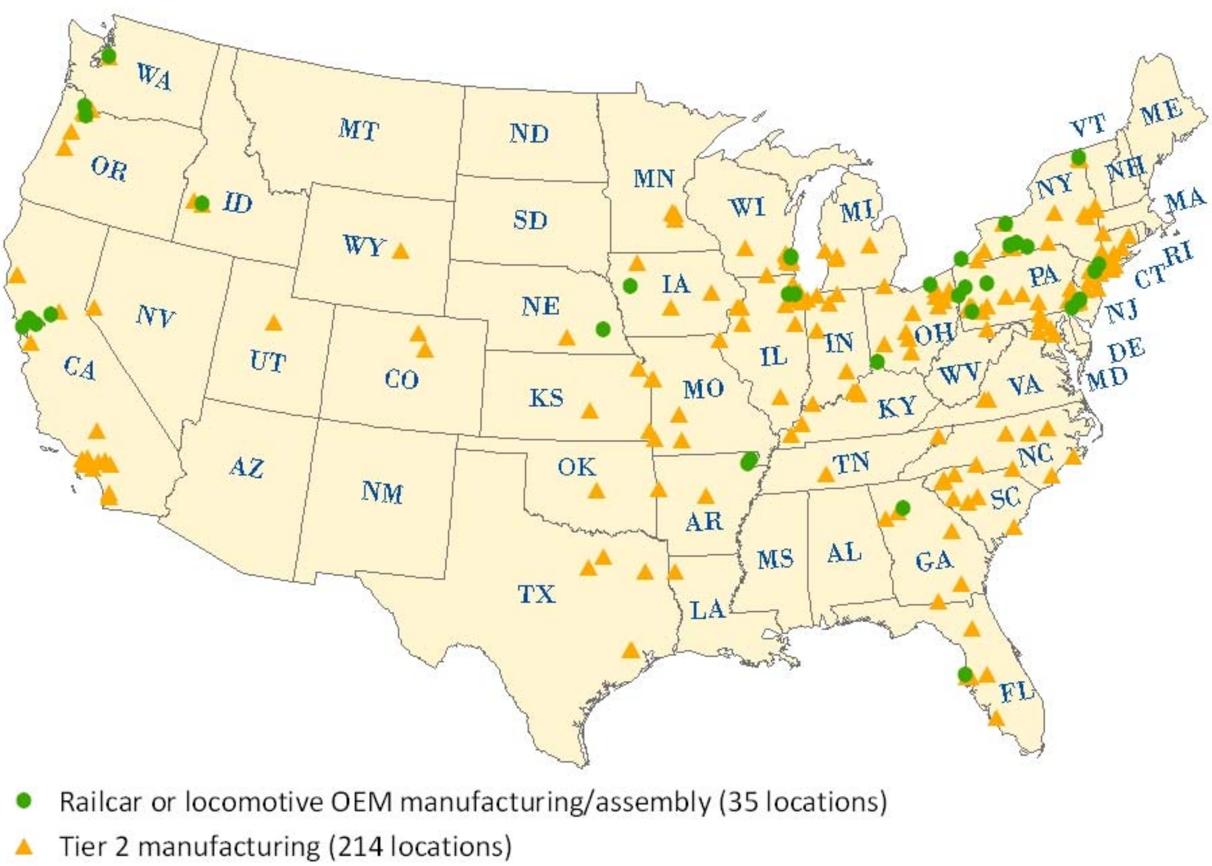
DMUs have gained popularity in non-electrified corridors throughout Europe and parts of Asia. A limited number of non-FRA-compliant DMUs are operating in New Jersey, Texas and California under agreements that require them to operate at times separate from freight trains, typically day vs. night. European and Asian car builders to date have been hesitant to produce FRA-compliant DMUs because the market has been too small and unpredictable to ensure adequate returns on upfront investments in engineering/design, tooling and other non-recurring development costs. Thus, US Railcar Company is hoping to leverage its position as proposed increased federal funding becomes available (Pracht, 2010).

[18] Meanwhile, in high-speed rail, Talgo is currently manufacturing the first FRA-compliant single-level trainsets (Friend, 2010).

U.S. manufacturing jobs in Tier 1 and Tier 2

Our research identified 214 Tier 2 U.S. manufacturing locations for passenger and transit rail vehicle systems and components. Tier 1 manufacturing and assembly locations numbered 35, for a grand total of 249 relevant manufacturing locations (see Figure 10).[19] These facilities are found in 35 states, primarily concentrated in states from Texas eastward, as well as the West Coast. The five states with the largest number of locations were New York (32), Illinois (23), Pennsylvania (26), California (22) and Ohio (13). The large number of suppliers in New York reflects the fact that the New York City metropolitan area is by far the largest market, and the three top car builders, Bombardier, Kawasaki, and Alstom, all have facilities in the state.

Figure 10. U.S. manufacturing locations for passenger and transit rail vehicles and components



Source: CGGC, based on industry interviews and company websites.

[19] For selected Tier 1 firms, rebuild sites are included.

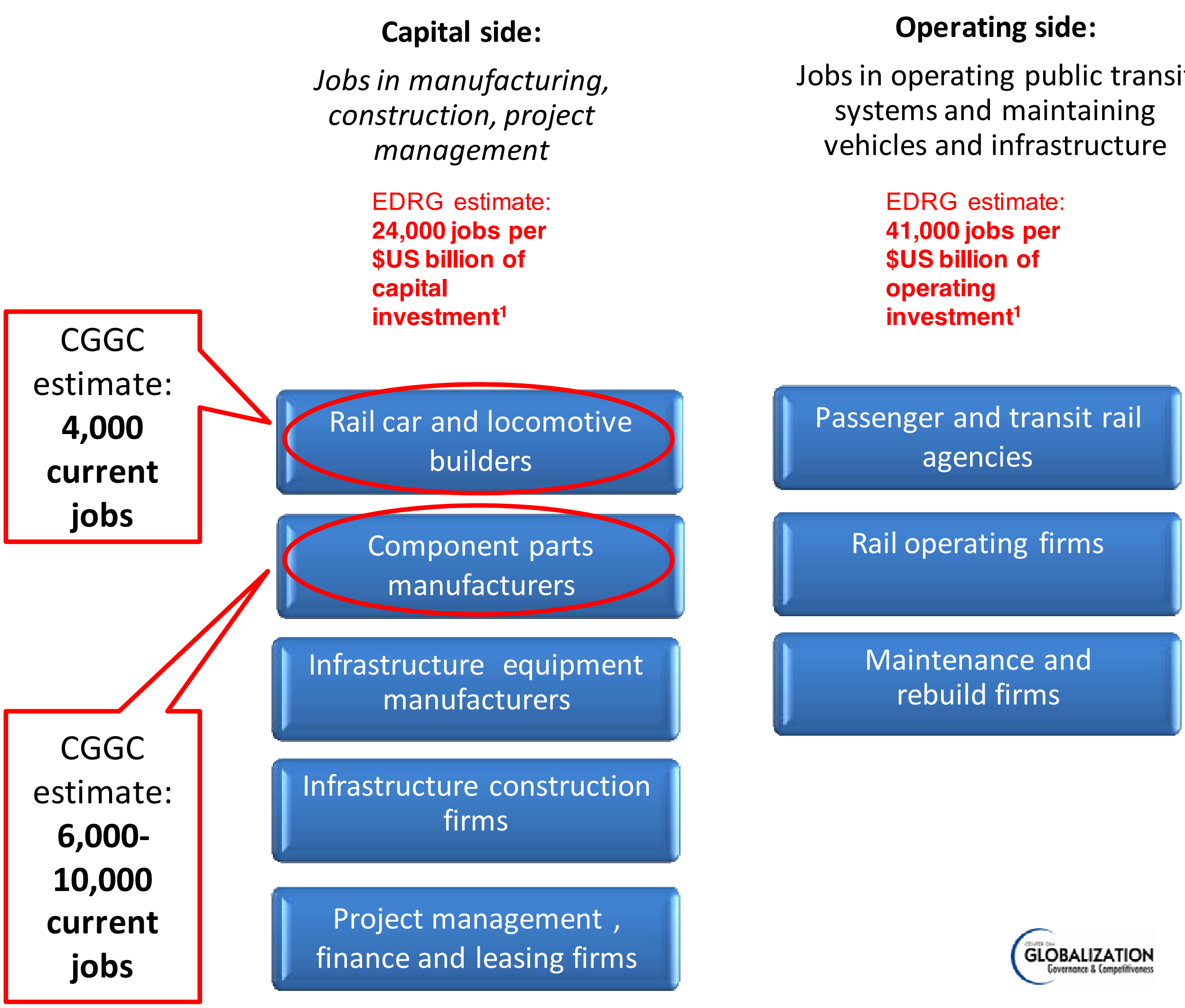
In addition to these existing locations, several firms are planning new or expanded facilities:

- Nippon Sharyo plans to open a facility in the Midwest to build shells (to be announced in June, 2010).
- CAF USA is anticipating an expansion to serve the U.S. higher-speed rail market, with no specific plans yet.
- Siemens just finished a $26-million expansion of its Sacramento, CA facility and expanded its U.S. work force by 50%.
- Talgo has announced it will open a manufacturing facility in Milwaukee, WI in August, 2010, the first U.S. manufacturing and assembly facility to build high-speed trains since the Acela. Talgo currently has two new orders for high-speed trainsets, one for the state of Wisconsin signed on July 2009 for two trains purchased with State funds with an option for two additional trainsets. A second order was signed with Oregon in February purchased with stimulus funds (Friend, 2010).
- US Railcar Company expects to build a new facility in the Midwest in the next two years to support DMU growth projections (Pracht, 2010).
- United Streetcar is currently expanding its Clackamas, OR facility, retrofitting a building to devote it specifically to streetcar fabrication. The company is also leasing an additional 35 acres for its facility and is now building a streetcar test track (Brown, 2010).

For several reasons, it is difficult to estimate how many jobs are represented by relevant U.S. manufacturing locations. First, many firms are privately owned and thus do not tend to make public such data as total employees or U.S.-based employees. Second, even when employment figures are available, many firms are very diversified, making it difficult to determine the number of employees that are devoted to rail versus other business segments. More difficult still is the task of discerning how many rail-related employees devote their time not to freight rail but specifically to passenger and/or transit rail.

Keeping these data limitations in mind, we made a rough estimate of the number of relevant U.S. jobs. We estimate that the Tier 1 and Tier 2 firms we identified represent 10,000 to 14,000 U.S. employees who devote at least a portion of their labor to vehicles and components for passenger or transit rail. This includes 4,000 jobs in Tier 1 and 6,000 to 10,000 jobs in Tier 2 (see Figure 11). We used different assumptions for each tier. For example, in Tier 1 we assumed that all passenger rail car OEMs are 100% devoted to passenger or transit rail in the relevant manufacturing locations. We assumed that for one locomotive company, Motive Power, which supplies locomotives for commuter rail, 50% of employees are devoted to these products. For locomotive makers GE and EMD, we assumed that only 1% of employees in the relevant manufacturing locations are devoted to passenger rail, reflecting the reality that Amtrak, their main U.S. customer, has not made an order in nearly a decade. In Tier 2, we assumed that the share of a company's sales devoted to rail products could serve as a proxy for the share of employees devoted to these products. We used the relevant % share for companies for which it was known, and for the few remaining companies, we applied a range of 10 to 30%. For very large, diverse corporations with tens of thousands of employees, unless indicated otherwise, we assumed that 1% of employees spend at least a portion of their time on passenger or transit rail. Similarly, for the few companies mainly selling freight products, we counted 1% of employees to be associated with passenger or transit rail.

Figure 11. Estimated current U.S. jobs in the manufacture of passenger and transit rail vehicles



[1]Estimates by Economic Development Research Group. Jobs are defined as "jobs supported for one year."

Source: CGGC; job estimates from (Economic Development Research Group, 2009).

Because the U.S. passenger and transit rail industry has not received substantial public investment for many years—thus keeping demand for new rail vehicles at a minimum—the manufacturing presence is small in job terms. However, these jobs may have a more positive impact than their numbers suggest. Compared with other job sectors, manufacturing is estimated to have the largest multiplier effect—generating $1.40 of added economic activity for each $1 of direct spending—and creating on average 2.5 additional jobs for each manufacturing job. By contrast, new service jobs, including those in high tech sectors, create an estimated 1.6 associated jobs (Hindery et al., 2009).[20] In addition, the majority of rail-relevant manufacturing facilities are in the Midwest/Northeast industrial states, in which the current economic recession has created the severest job losses. There is a modest degree of overlap between the rail vehicle industry and the motor vehicle industry; about 15% of Tier 2, or 24 firms, serve both industries (these firms are marked with a * in Table 9). If current trends continue and the passenger and transit rolling stock market continues to grow, these firms—and their Tier 3 suppliers—may welcome the opportunity to supply a market that is actually growing in the midst of the economic downturn.

Future of the U.S. supply base

Our main finding on the future of the U.S. supply base for manufacturing passenger and transit rail vehicles can be summarized as follows:

<u>For the domestic industry to develop fully, much larger and more consistent U.S. investments in passenger and transit rail are needed</u>. The small size of the U.S. market for passenger and transit rail limits development of domestic companies. The international passenger and transit rail vehicle and component firms that figure prominently in the U.S. market are headquartered in countries with stronger markets, mostly in Europe and Asia. Our research results regarding the future of the U.S. supply base for manufacturing passenger and transit rail vehicles consistently emphasized this need for increased, steady demand.

Additional findings can be summarized as follows:

<u>a) The positive impact of Buy America and Buy American rules can be enhanced by improving accountability, heightening transparency, and offering incentives to increase vehicles' share of domestic content</u> . Domestic content requirements have helped develop a robust U.S. component supply chain and give vital opportunities to U.S. firms. Given that domestic demand for passenger rail vehicles has been very limited for decades, it is largely thanks to Buy America that the domestic supply chain is already quite well developed. However, several firms noted that problems remain in the accounting and auditing process for certifying domestic content. Large differences remain in the way firms determine U.S. content, with some finding ways to disguise foreign-manufactured content, thus disadvantaging those

[20] At the upper end of this job multiplier, each high-tech manufacturing job is estimated to create 16 associated jobs.

that closely follow the rules. A common theme is that auditing needs to be improved and loop holes closed so that all firms are playing fairly.

For transparency, it is important that domestic manufacturers have access to complete, timely information about waiver requests. For example, the DOT could post relevant waiver requests on a public website. This way, if a firm has claimed that, for a given component or material, there is no available or reasonably-priced alternative manufactured in the United States, domestic manufacturers would then be able to contest that claim before a waiver has been needlessly granted (Donato, 2010).

Positive incentives could also be offered to increase the share of domestic content. Federal funding mechanisms could be designed to reward projects in which the share of domestic content will be higher. To have the intended effect, these incentives would need to be accompanied by additional measures to improve transparency, so that state and local governments and transit agencies can make useful comparisons of the U.S. content provided by potential suppliers.

b) To stabilize the market and bring down costs, it is important to revisit U.S. standards and specifications and promote their use. For intercity passenger rail, section 305 of the Passenger Rail Investment and Improvement Act of 2008 (PRIIA) established a committee to work out national component standards for wheel sets, doors, air conditioning modules, and the like. The committee comprises members from FRA, Amtrak, state representation, and manufacturers, with a goal to increase the volume of component manufacturing, improve interchangeability between equipment suppliers, and enhance sustainability for rail operations (Harwig, 2010). If this ambitious work succeeds in creating industry-wide standards that allow features to be modified for specific needs (similar to the aviation industry), the passenger rail industry should enjoy more stability and enable new firms to enter the market with less risk regarding engineering and design. For transit rail categories, APTA is coordinating the development of new standards that should provide similar benefits, stabilizing the market and enabling transit agencies to pool vehicle purchases and achieve economies of scale.

c) To help capture higher value activities in the supply chain, a combination of measures is needed, including technology agreements, government support for research and development (R&D), and a collaborative, orchestrated approach to innovation, supply chain development, and commercialization. Buy America alone is considered insufficient to build higher value within the manufacturing base for U.S. passenger and transit rail. In many cases, firms satisfy Buy America requirements by using U.S. subcontractors for lower-value manufacturing, while keeping high-value engineering and intellectual property in other countries. Our interviews suggest that for OEMs in Tier 2 as well as Tier 1, engineering may take up at least the first year of a contract. Firms mentioned several additional measures that could potentially help capture this higher value, including technology agreements, joint ventures, and joint licensing with lead firms. The right mix of such measures could make it more feasible for new U.S. players to emerge and be able to compete against the experience and expertise of large international OEMs.

To further enhance U.S. firms' position in higher-value activities, government support of research and development (R&D) can be very strategic, as demonstrated by the $2.4 million federal grant that enabled United Streetcar and Rockwell Automation to develop a new, U.S.-made propulsion system for modern streetcars. Incorporating these U.S. propulsion systems will increase the U.S.-made content of United Streetcar vehicles from the current 70% to 90% (Brown, 2010). Also needed in order to enhance relevant R&D—now fragmented among a few small research centers at universities—is a well-developed education base, perhaps including institutions similar to the major research centers that have spurred technology development in the automotive industry. A collaborative, orchestrated approach is needed to ensure that new developments carry all the way through to commercialization. An example of an effort to meet this need is Edison Welding Institute, (EWI), a not-for-profit R&D firm in Columbus, Ohio. EWI recently established the Passenger Rail Manufacturing Center to promote private-public collaboration. The center aims to facilitate commercialization of advanced technology through innovation, supply chain development, prototyping, testing, and training (Harwig, 2010).

Conclusion

This study uses a value chain approach to address the impact of U.S. manufacture of passenger railcars and components on domestic jobs and U.S. competitiveness in the transportation sector. The analysis considers all Tier 1 and Tier 2 segments of the supply chain, highlighting critical roles and the extent to which they are fulfilled by U.S. capabilities. Many elements of a comprehensive supply chain are already in place, but important gaps remain, areas in which specific activities are typically not performed in the United States. The value chain framework provides a tool for identifying these gaps as opportunities for U.S.-based firms to grow the domestic railcar industry and capture-higher value manufacturing activities in the supply chain.

Manufacture of passenger and transit railcars and locomotives comprises an estimated 10,000 to 14,000 U.S. jobs. These represent a market that to date has been limited by much lower investments in passenger and transit rail than those of the nation's economic competitors. If the United States is to continue to increase its commitment to rail transportation, as suggested by stimulus funding and current proposals for the nation's six-year surface transportation bill, U.S.-based firms may well have the opportunity to further develop the supply chain and move into higher-value activities, supporting more jobs. These manufacturing jobs constitute just one portion of total employment created by public transit investments, which includes many more jobs in additional segments such as construction and operation.

Continuing to make much larger and more consistent investments in intercity passenger and urban transit rail would help the United States embrace a larger vision of the transportation energy future. Additional measures to help grow the domestic rail industry include making improvements to Buy America and Buy American rules, revisiting U.S. standards and specifications, and adopting a collaborative, orchestrated approach to expanding the technical knowledge base required to further develop the domestic supply chain and carry innovations all the way through commercialization.

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