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Guidebook for Railway-themed K-12 STEM Outreach Activities

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Introduction

Welcome to the *Guidebook for Railway-themed K-12 STEM Outreach Activities*! Inside, you will find descriptions of educational activities designed to introduce students to the railroad transportation mode through the lens of STEM (Science, Technology, Engineering, and Mathematics) concepts.

Railroads have been a critical part of the global economy since the 1830s. Today, railroads haul more ton-miles of intercity freight (one ton of freight moved one mile) than any other mode of transportation in the United States. While the railroad industry is the leader in long-haul freight transportation, recruiting students to leadership roles in the industry is challenging. With many railroad employees approaching retirement age, the need to raise student awareness of railway industry career opportunities has never been greater.

The activities in this guidebook cover a wide variety of railroad topics. The activities are intended to be hands-on to provide students with knowledge through experiential learning that also increases their awareness of railway transportation technology. Although the following chapters provide a step-by-step guide to each activity, we encourage you to experiment with modifications to each activity and to create your own activities on other facets of the railroad industry and STEM topics.

We hope you find the activities in this guidebook to be informative and entertaining!

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Railcar Puzzle and Commodity Matching Game

This puzzle matching game introduces different types of freight railcars and the commodities they carry.

Number of Participants: 1-2 **Recommended Age:** 3+

Setup Time: 3 minutes **Activity Time:** 1-5 minutes

STEM Concepts:

- *Technology: railcars incorporate various design features according to commodity properties*
- *Engineering: railway operators must match the number and type of railcars to their traffic*
- *Mathematics: geometric properties such as shape, length, height and volume are key differences between different types of railcars*

Key Learning Points

1. **There are many different types of railcars designed to fit the needs and characteristics of different types of commodities shipped by rail.**
2. **While some types of railcars are general purpose and can carry a range of freight, other railcars are designed specifically for transporting one type of commodity (examples include "autoracks" for transporting motor vehicles or coil cars for carrying rolls of steel).**

Background

Railroad locomotives and freight cars (or "rolling stock") come in all shapes and sizes. Why is that?

- Some types of freight require protection from the weather, while others do not.
- Some commodities are solid, while others are liquid or gas.
- Some shipments are granular or will flow, while others are solid and fixed in shape.
- Some types of freight require special handling to be sure they will arrive safely.
- Shippers may want to load or unload a railcar from the side, end, top and/or bottom.

To meet the distinct needs of each commodity or type of freight shipped by rail, the railroads and railcar manufacturers have develop different types of railcars to efficiently transport different materials. Each type of railcar possesses a unique combination of features, including:

- Length, height, volume and overall shape (rectangular, cylindrical, ellipsoidal)
- Fully enclosed with a roof or open to the weather
- Doors on the sides or ends for loading and unloading
- Hatches in the roof for loading and/or outlets in the floor for unloading
- Special fittings for loading or unloading liquids or pressurized gasses

This activity aims to familiarize participants with different types of freight cars and the commodities that they are designed to carry.

While technically not a railcar, nearly all freight trains in the United States are powered by one or more **diesel-electric locomotives**. The diesel-electric locomotive uses an internal combustion engine powered by diesel fuel and an alternator to generate electricity. The electricity is used by electric motors mounted on each axle that provide the power to turn the locomotive wheels and move the train. Typically two crew members control the train from the locomotive cab. Connections between locomotives allow the crew in the cab of one locomotive to control other locomotives it is coupled to. Radio signals can also allow the crew at the front of the train to also control locomotives located at the rear or middle of the train. The locomotive also provides braking force to stop the train when needed, and carries lights, a horn and a bell to help warn pedestrians and motorists at highway-rail grade crossings.

Figure 1: Typical diesel-electric freight locomotive. Used to provide propulsion for the train.

Boxcars were once the most common type of freight car and are used to carry materials and packaged goods that require protection from the weather but cannot by shipped loose in bulk.

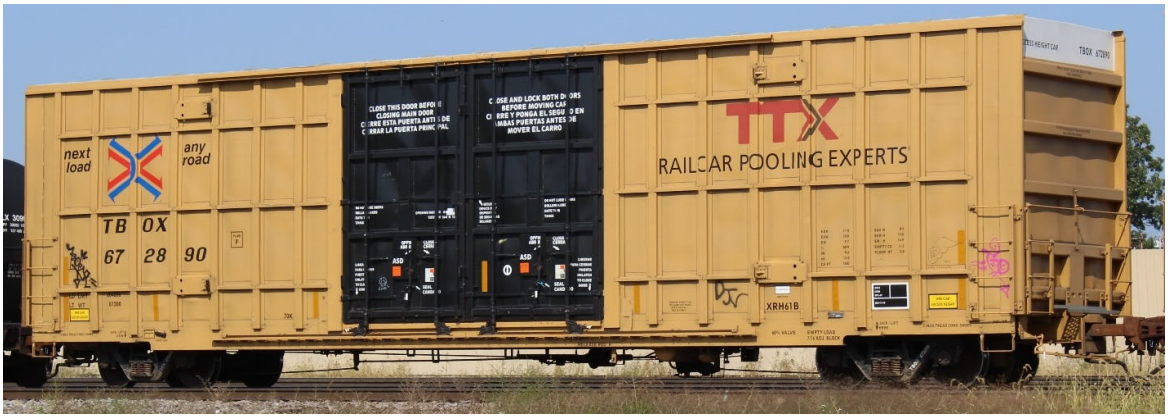

Figure 2: Box car. Transports rolls of paper, building materials, auto parts, packaged freight and other goods that are sensitive to the weather.

Much of the freight that was once shipped in boxcars is now shipped in **shipping containers** and **highway trailers** that can move on both truck and rail in "intermodal service". Containers can also transport freight overseas via ship. Containers and trailers transport consumer goods such as appliances, bicycles or packages from online retailers. Specialized intermodal railcars are used to transport the containers and trailers between terminals where cranes and other specialized equipment lift them on and off the train.

Figure 3: Intermodal well car and two containers "double-stacked" on top of each other.

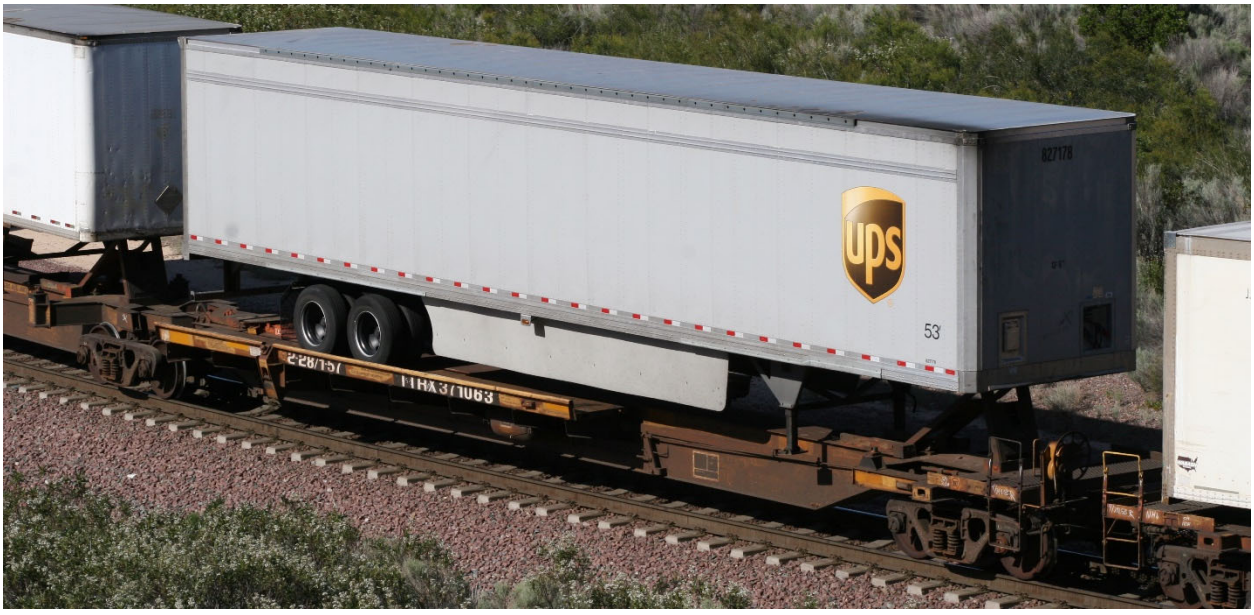

Figure 4: Intermodal spine car carrying highway trailer.

Railways often transport commodities that are shipped loose or in bulk. These materials may be granular or liquids or gasses that flow and conform to the shape of the railcar. Railcars designed for these products include open and covered **hoppers**, **tank cars** and **gondola cars**. Railcars used to transport bulk commodities may have an open top, roof hatches or a top fitting for loading materials, and may also have bottom outlets or fittings for unloading.

Figure 5: Open top hopper. Used to haul loose commodities that can withstand water such as gravel or coal.

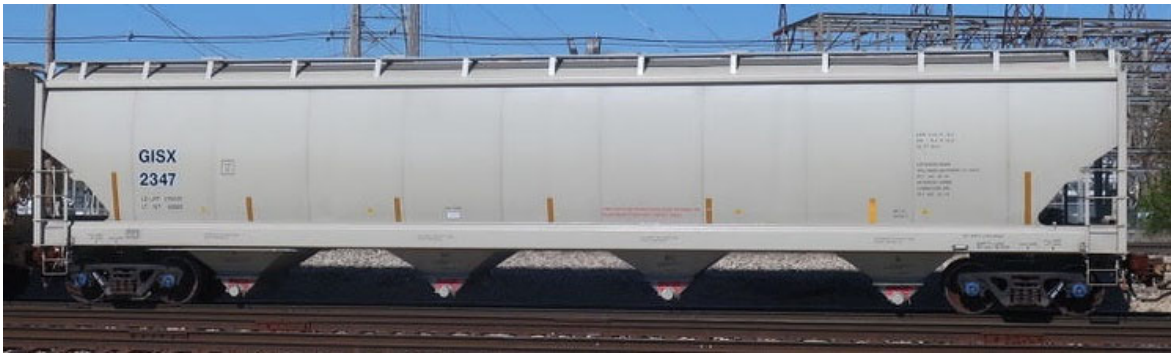

Figure 6: Covered hopper. Used to haul loose commodities that cannot withstand water such as grain, salt, fertilizer, sand, or plastic pellets.

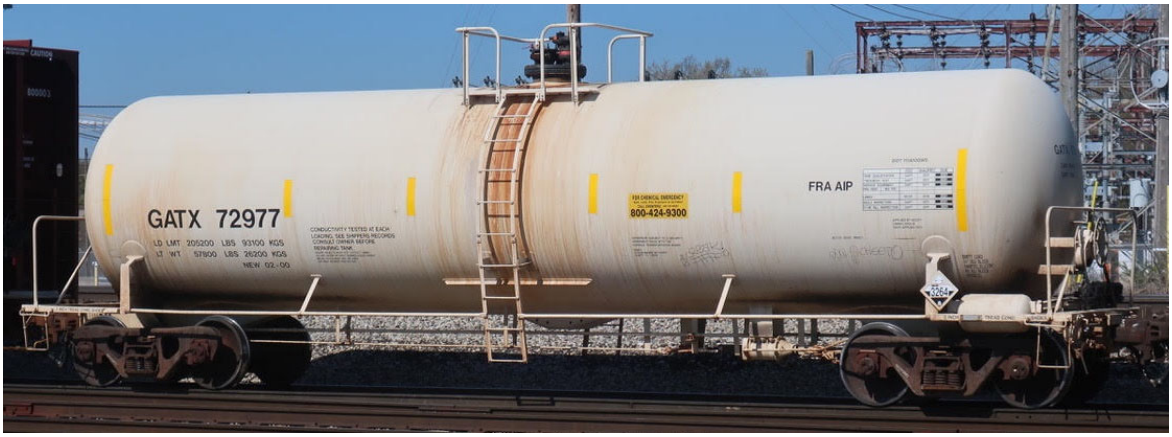

Figure 7: Tank car. Used to haul liquid commodities or pressurized gases such as propane, chemicals, crude oil, ammonia, ethanol, gasoline or corn syrup.

Figure 8: Gondola car. Used to transport commodities that are not sensitive to water such as rail, scrap steel, or pipes.

Certain shipments are discrete objects such as automobiles, steel shapes, machinery and other equipment. Specialized railcars are correctly sized for these shipments and have different features to protect the freight and secure it in place when moving from origin to destination.

Figure 9: Autorack car. Transports finished motor vehicles from assembly plant to distributor.

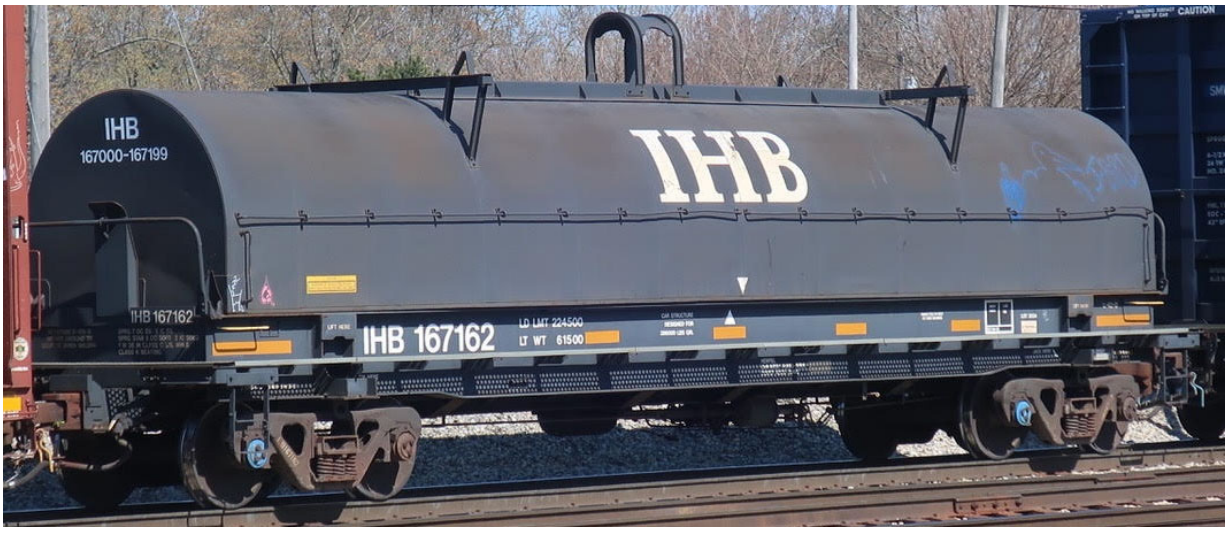

Figure 10: Coil car. Transports steel coils from steel mills to various manufacturers.

Even **flat cars,** with a long level platform for shipping large loads that do not require any protection from the weather, come in different varieties. In addition to containers and highway trailers, flat cars are used to transport a wide range of other large loads that do not need to be transported inside a railcar.

Figure 11: Flat car. Transports commodities that do not fit in other car types or do not need protection from the weather such as machinery, pipes, and poles (as pictured). Flat cars can come in many configurations with special equipment for the specific commodity being carried (for example, the car pictured has stakes to help hold the poles on the car).

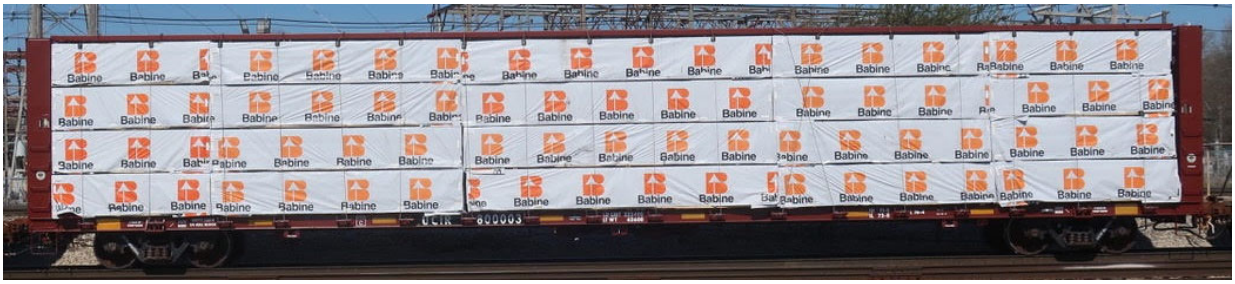

Figure 12: Centerbeam flat car. Transports lumber products.

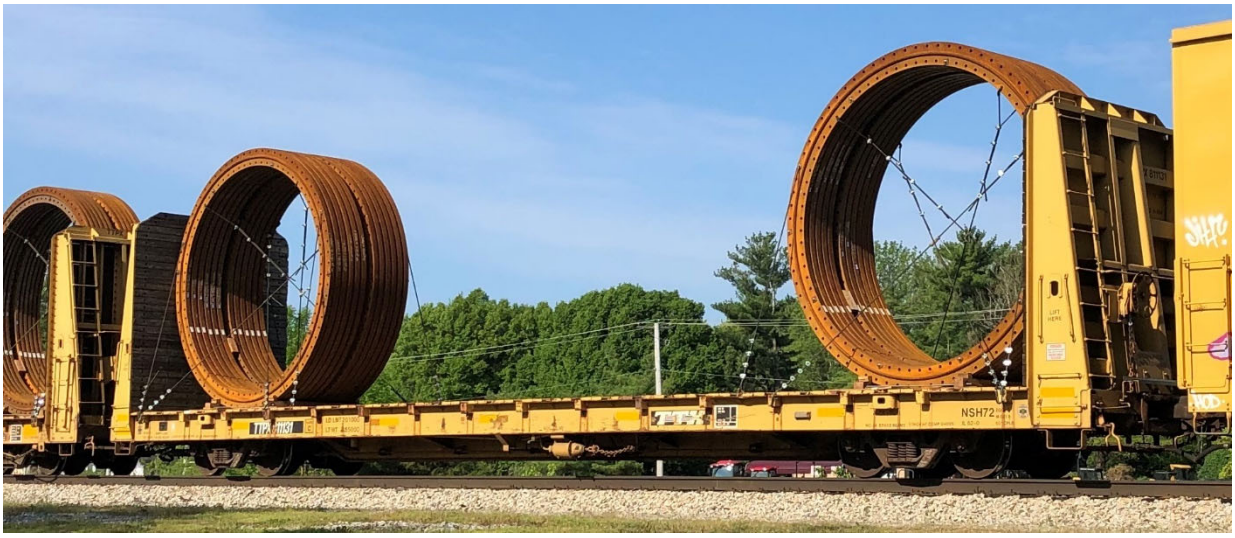

Figure 13: Bulkhead flat car. Flat car except equipped with vertical bulkheads to prevent shipments from sliding off the end of the car. Transports commodities such as pipes or beams.

In addition to freight cars, railroads have various other pieces of equipment that move in trains or individually on the rails under their own power. This equipment may be used to ensure safe train operations, move railcars at industrial facilities, or help maintain and repair the track.

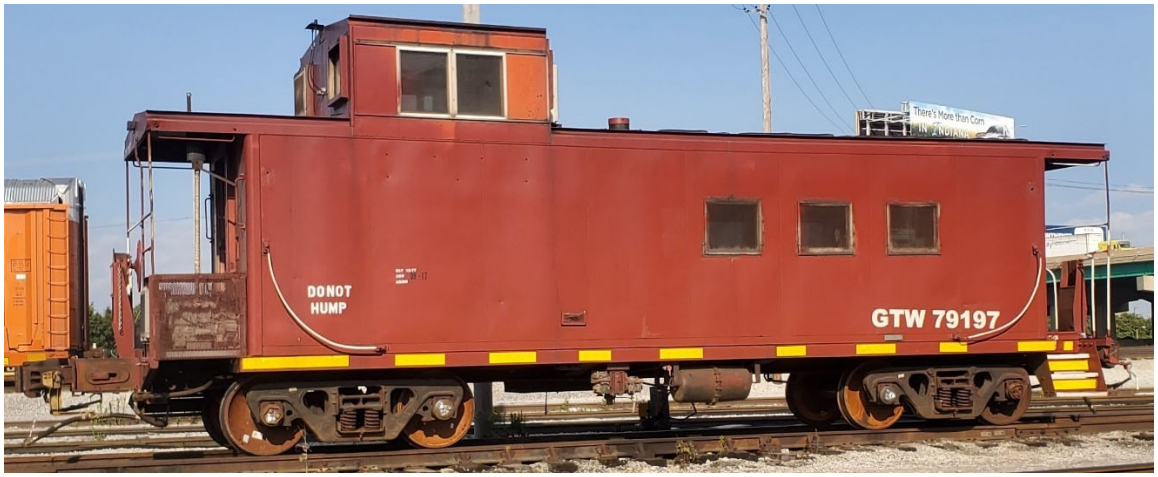

Figure 14: Caboose / shoving platform. A place for the conductor and other crew members to ride, now only used in local freight service as a platform on which crews can stand rather than riding on the side of a freight car.

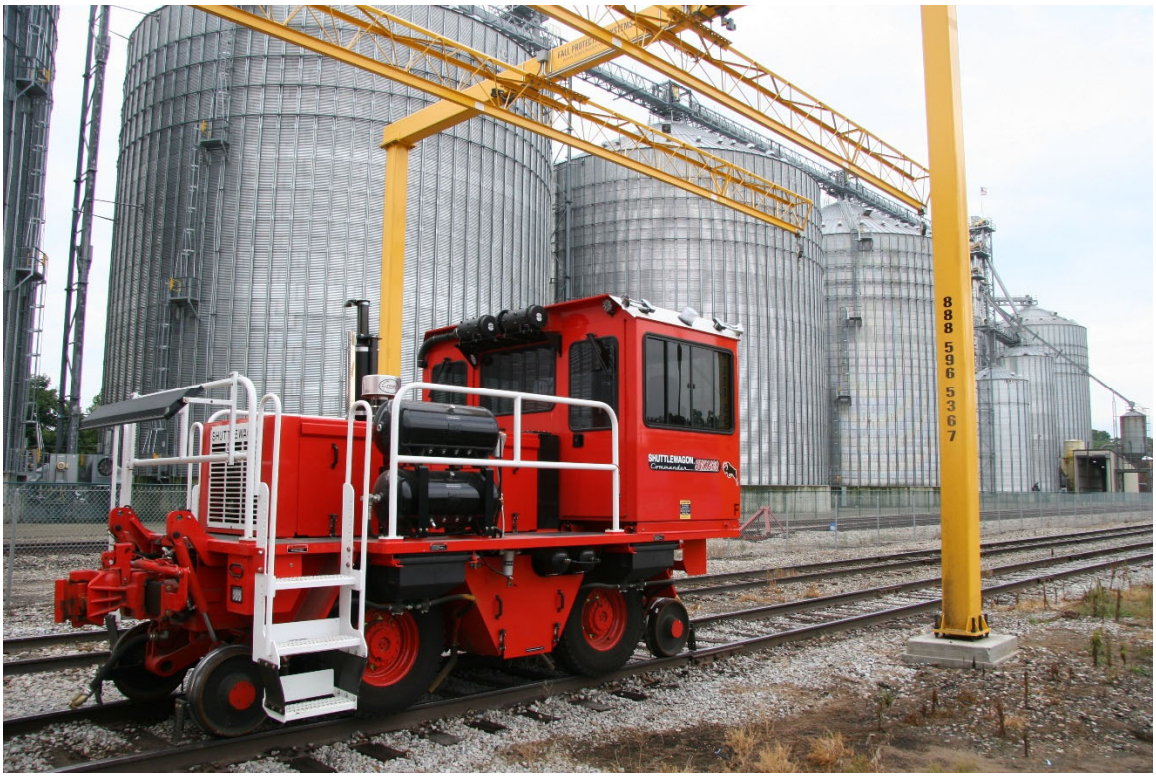

Figure 15: Railcar mover. Although not found in trains, railway shippers, such as this grain elevator, may use a railcar mover instead of a locomotive to shift individual railcars for loading or unloading at a rail-served industrial facility. Railcar movers also have rubber tires that allow them to also use roadways to move around a facility.

Materials List and Setup

Materials:

This activity can be conducted and constructed with a variety of different materials. Options include:

- Railcar and commodity matching game with one set of labelled railcar pictures and another set of images depicting different commodities that match a specific railcar. The railcar pictures and commodities can be printed on cardstock and laminated for re-use. Participants must match the commodity "cards" to the correct railcar picture taped to a table.
- Model railway cars with labels can also be used for the matching game in place of the railcar pictures. Commodity images on laminated cards could be matched to the correct railcar, or samples of different commodities in small clear plastic containers could be used for matching.
- A "railcar puzzle" (Figures 16 and 17) featuring a wooden game board with removable railcar cutouts. The puzzle was constructed from two layers of plywood, with the bottom layer serving as a base. Before being affixed to the bottom layer, a jig saw was used to cut out several "puzzle pieces" shaped like a locomotive and different types of railcars in the overall pattern of a train. The removable cutout puzzle pieces are decorated with an image depicting the outside of the railcar, while an image of the commodity corresponding to that railcar is inserted into the cutout where the railcar fits. A cutaway view showing the diesel engine, cab, and other internal components can be used for the locomotive.

Regardless of the materials used, a set of railcar types and commodities can be selected from the figures presented on the previous pages to show the range of railcars and types of freight shipped by rail.

Side views of cars and locomotives for use in construction of a puzzle or matching game can be found on the internet: http://paintshop.railfan.net/home.html

Figure 16: Puzzle showing locomotive puzzle piece and cutaway view in puzzle board cutout.

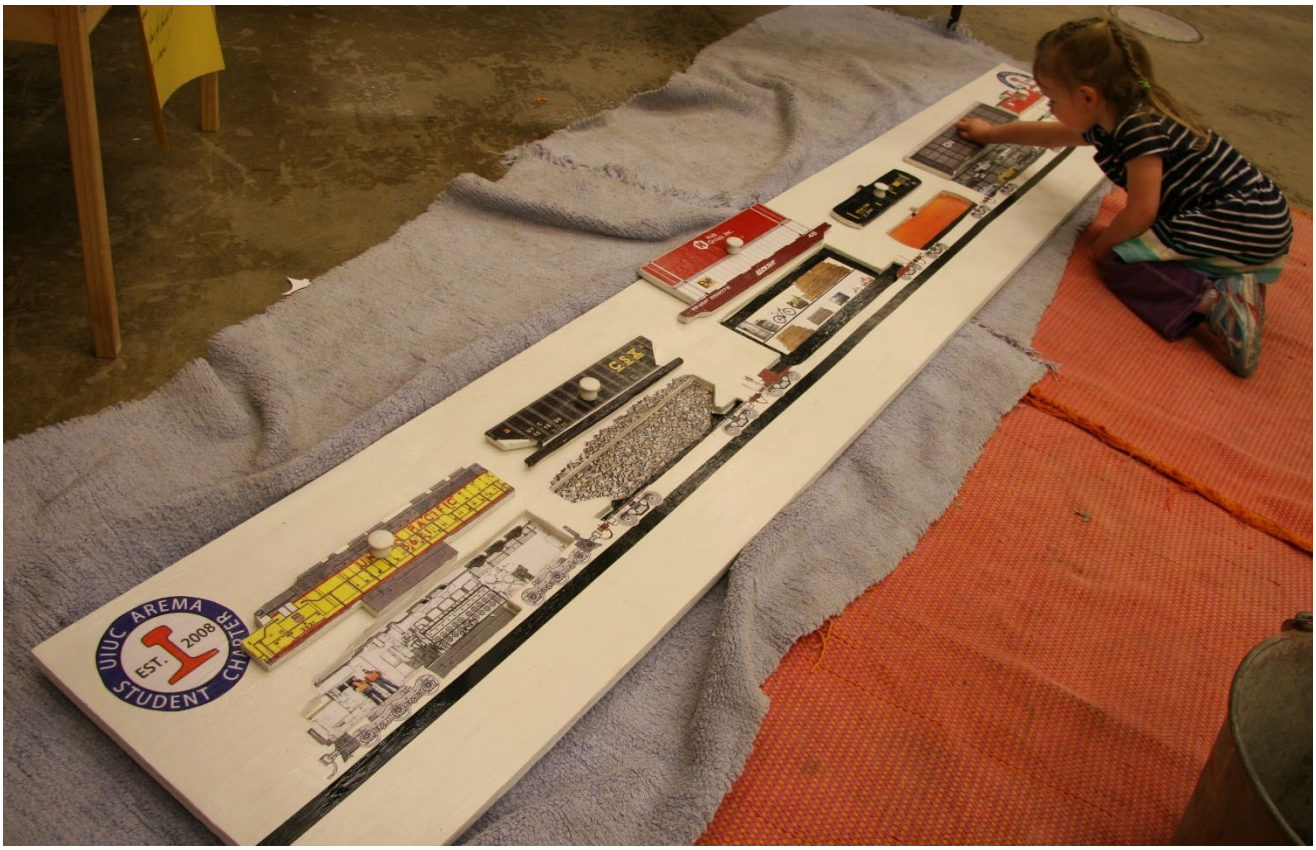

Figure 17: Wooden railcar puzzle constructed with wooden car cutouts forming a train composed of a locomotive, open hopper, double-stack container well car, tank car, autorack and caboose.

Script

This activity can be conducted as an interactive activity with an activity leader, or it can be setup as a display. The puzzle option works well as a display since the shape of the puzzle pieces guides participants to the correct answers without any supervision or guidance. When conducted with an activity leader, participants engage in a matching game between the types of railcars and commodities.

- Begin by asking the participants what trains carry. Naturally, there are a wide range of correct responses.
- After some discussion, explain that such a wide variety of commodities require a wide variety of railcars to carry them. Provide the participant with the commodity cards if being used.
- Introduce the railcar types and have the participant try to match the commodities with the appropriate railcar type by matching the commodity card to the correct railcar picture or model, or placing the correct railcar puzzle piece in its matching commodity cutout opening.

If using railcar and commodity pictures and there is more time for each participant, or the activity is being used a demonstration for a group, the matching game could also be played like “Memory”. Place all of the railcar and commodity picture cards face down and have the participants take turns flipping over two cards at a time until they successfully match railcars and commodities.

Questions to Stimulate Student Thought

1. What are some reasons that freight is hauled in different car types?
2. How many different freight car types can you name?
3. What are some other commodities transported by railroads and what kind of railcar is required to transport them?
4. Why might railcars of the same type have different lengths, sizes and shapes? *(See the Railcar Size and Weight activity description for additional ideas on this topic)*

Adjusting for Time and Participant Age

1. This activity can be lengthened or shortened by increasing or decreasing the number of railcar types in the puzzle or matching game.
2. For older participants, ask them if they can think of some kinds of freight that may be moved in each car type (see question 3 under *Questions to Stimulate Student Thought*).
3. This activity can serve as a good lead-in for the Railcar Size and Weight activity that conducts a more detailed exploration of the relationship between railcar size, weight and shipment density.