Chapter 10

Rail Planning

Rail planning consists of determining what type of rail system is needed. It also includes what type of services will be used and who will use and maintain the rail system.

RAILWAY INTELLIGENCE

10-1. Rail line and equipment planners and operators, either before or after entry into the theater of operation, should gain as much information as possible on the rail system that they will be using for operations. The following is a sample listing of information that they should maintain for operation.

- **Types of locomotive.** Their manufacturer, model, horsepower number, gauge, mechanical condition, and if spare parts are available in area of operation.
- **Types of rolling stock.** Numbers, loading limits, repair condition, part availability, and distribution within the system.
- **Signal system.** Type, automation (if any), state of repair, and effectiveness.
- **Track structure.** Size and type of rails, condition of crossties, rail and ballast, washout and rockslide potential, number of single and double main lines, and the availability of sidings or passing tracks.
- **Layout of system.** Branch lines, grades, curves, bridges, tunnel and clearance limitation (both height and side clearance).
- **Methods of operation.** Fleet, block, or automation method. A very good system of electronic communication must exist and be put to use by the rail system.

Other matters concerning railway intelligence may be found in Chapter 3.

RAIL OPERATIONS PLANNING

10-2. Staff and planning functions for theater rail operations are the responsibility of the commander of the highest echelon of the unit in the theater. The railway plan that is developed is integrated into the overall movements plan for the theater. Selected personnel of the transportation railway battalion obtain the most detailed intelligence data through reconnaissance of captured or liberated rail lines, with augmentation by personnel from higher echelon rail units. Railway battalion commanders, who have been assigned a division of rail line, conduct a reconnaissance of their respective rail divisions and gather intelligence data. They then make estimates of the time required to get the line operational and the capacity or net tonnage that can be moved over the line. All intelligence information collected and plans and estimates formulated are forwarded to the next command level. Here all the information and estimates from the battalions are consolidated to form the transportation rail plan. The planner must make assumptions based on the information he has and on past rail operations experience if the required information is not available or cannot be easily obtained. The following are some important items a planner should consider:

- The strategic importance and selection of certain rail lines. Planned strategy attack, probable objective of the operation, lines of advancement, and enemy strengths and dispositions all influence the selection of primary and alternate rail lines.
- Details shown on maps and photographs (such as the rail routes, the number and location of railway facilities, and the number and kind of structures).
- A general description of the rail system (its facilities and its equipment). These descriptions help the planner to determine the potential capacity of the system and the importance of the system in the economic structure of the country in which it is located. Descriptions should also give information about the ownership of the railroad, its general operating procedures, and its organization.
- Detailed basic characteristics of routes, facilities, equipment, structures, and operations. These details help the planner to estimate a more accurate rail capacity. Intelligence data should include details on such items as right-of-way, roadbed, and track; types and amount of equipment; supply and maintenance factors such as spare parts, enginehouse facilities, and fuel and water stations; and availability of personnel.

- Types of gauges and classification of railways in the area. General gauge classifications are standard, broad, narrow, and meter. For defensive reasons, neighboring countries often do not construct railways having the same type of gauge. Such a precaution ensures that one gauge does not operate on another.

10-3. The planner must also consider physical features of the area when selecting railways. Considerations include the following:

- **Adequate yards, terminals, and shop facilities.** Without adequate yards and terminals, main lines become congested. Terminal yards should have sufficient track for receiving trains, classifying cars, and making up trains for departure. Tracks should be long enough to receive the longest train (without dividing it into segment(s)) intended to operate on that rail division. Facilities are needed to spot cars, unload them, and promptly return the empties to service. A terminal should include an enginehouse; car repair tracks; fuel, lube, sanding, and water stations; and buildings to house crews of the railway battalion. The heavy repair and maintenance of rail equipment require adequate shops located at or near yards and terminals.
- **Single, double, or multiple tracks.** Train density and overall rail capability are greatly affected by the type and number of tracks. If there is a usable double track, trains may operate in both directions without delays in schedules. However, the unit often takes the usable parts of a damaged double track to make one single main line with good passing tracks.
- **Seasoned roadbed, good ballast, and heavy rail.** The roadbed, ballast, and weight of the rails affect the speed and weight of trains. If the railway with the most seasoned roadbed, the best ballast, and the heaviest rail is selected, the number of interruptions in train operations caused by washouts and buckled rails are generally reduced.
- **Slight grade and curve.** Trains operated in mountains with steep grades require more motive power. Steep grades usually require pusher engines at the rear of a train, two or more locomotives pulling or doubleheader at the front of a train, or shorter trains. Train operations in mountainous terrain also reduce the train’s speed. Strong pulling and sudden braking are hard on railcars and sometimes cause derailments. These cars require more maintenance than those used on fairly level grade.

- **Running time.** Running time is greatly increased if the line has sharp or long curves. A speed that can be reached on a straight run of track cannot be maintained on a curved track. The ideal railway, with no grades and no curves, is never realized. However, the rail lines with the slightest grade and the fewest, gentlest curves should be selected.
- **Adequate sidings and spurs.** Passing tracks should be long enough to permit the longest train on the division to be able to completely clear the main-line track. Sidings and spurs are desirable, but they are not a major basis in selecting rail lines.
- **Strong bridges and tunnels of sufficient clearance.** The strength of railway bridges directly affects the kind of locomotives operated over them. If bridges must be rehabilitated or constructed, they must be strong enough to support the locomotive and the desired train weight. Any tunnels on the railway should have enough clearance for wide and high loads (such as bulldozers and cranes) to pass.

10-4. When selecting rail lines, care must be taken to select those that are the least vulnerable to traffic interruption. The following are some potential bottlenecks, which are vulnerable to enemy action or natural forces.

- Tunnels.
- Long, high bridges or bridges over deep streams or valleys.
- Deep cuts and high fills.
- Limited access terminals or yards.
- Tracks located adjacent to banks of streams. These tracks are subject to the erosive action of flood waters.
- Restrictive clearance points. Tracks running through cuts where land and rock slides are common.

LINE CAPACITY PLANNING

10-5. While most military supply movements are primarily forward, military rail-line capacity estimates are usually based on net tonnage moving in one direction. However, total capacity is based on train density and must take into consideration movements of the train in both directions. When the railway net under consideration is made up of several divisions and/or branch lines, separate estimates should be made for each rail division and branch line. Use the following factors, formulas, and computations for planning considerations. Since locomotives are prime power units, their hauling capabilities must be established. Therefore, to establish a locomotive's pulling power, certain factors must be computed. The factors used are for initial planning and worse case situations. Once implemented, or if intelligence data permits, plans may be modified.

TRACTIVE EFFORT

10-6. Tractive effort is a measure of the potential power of a locomotive expressed in pounds. It is the horizontal force that a locomotive's wheels exert on a straight, level track just before the wheels will slip on the rails. A locomotive's tractive effort is included in the data supplied by the manufacturer. Where such data are not available, tractive effort may be determined as described in paragraphs 10-7 and 10-8.

Starting Tractive Effort

10-7. The power exerted by a locomotive to move itself and the load that it is hauling from a dead stop is STE. It is correlated closely to the adhesion that the driving wheels maintain at the rails. If the tractive effort expended exceeds this adhesive factor, the driving wheels will slip. Normally, the adhesion factor when the rails are dry is 30 percent of the weight on drivers. When the rails are wet, this factor is reduced to 20 percent. However, for planning purposes, 25 percent is used. For a diesel-electric locomotive weighing 80 STONs or 160,000 pounds on the driving wheels, the STE is computed as follows:

$$STE = \frac{\text{Weight on drivers (pounds)}}{\text{25 percent adhesion factor}}$$

$$= \frac{\text{160,000 pounds}}{4}$$

$$STE = \text{40,000 pounds}$$

Continuous Tractive Effort

10-8. CTE is the effort required to keep a train rolling after it has started. As the momentum of a train increases, the tractive effort necessary to keep the train moving diminishes rapidly. The CTE of a diesel-electric locomotive is approximately 50 percent of its STE. The locomotive cannot continue to exert the same force while pulling a load as was attained in starting that load. The CTE of a diesel-electric locomotive weighing 80 STONs or 160,000 pounds on the driving wheels is computed as follows:

$$CTE = \frac{STE}{2}$$

$$= \frac{\text{40,000 pounds}}{2}$$

$$CTE = \text{20,000 pounds}$$

DRAWBAR PULL

10-9. Drawbar pull is the actual pulling ability of a locomotive after deducting from tractive effort, the energy required to move the locomotive itself. In planning, 20 pounds per ton of total locomotive weight is taken from the tractive effort as follows:

Total locomotive weight = 80 STONs

80 X 20 = 1,600 pounds

CTE – 1,600 pounds = DBP

or

$$STE = \frac{160{,}000}{4} = 40{,}000$$

$$CTE = \frac{40{,}000}{2} = 20{,}000$$

DBP = 20,000 – 1,600

= 18,400 pounds

10-10. Maximum DBP can be exerted only at lower speeds (up to about 10 miles [16 kilometers] per hour) and for a limited length of time. At higher speeds, diesel-electric locomotive DBP diminishes rapidly because the electric generator and traction motor cannot hold up under the heavy starting voltage and amperage. The generator and motor would also burn out if the load continued for a longer time after the locomotive reached a speed of 10 MPH.

ROLLING RESISTANCE

10-11. The force components acting on a train in a direction parallel with the track which tend to hold or retard the train's movement constitute rolling resistance. The following are the components of RR:

- Friction between the railheads and the treads and flanges on the wheels.
- Resistance due to undulation of track under a moving train.
- Internal friction of rolling stock.
- Resistance in still air.

Although there is no absolute figure to be used as RR, Table 10-1 shows the safe average values to use in a theater of operations.

GRADE RESISTANCE

10-12. Grade resistance is the resistance offered by a grade to the progress of a train. It is caused by the action of gravity, which tends to pull the train downhill. In military railway planning, use the factor of 20 pounds multiplied by the percentage of GR.

CURVE RESISTANCE

10-13. Curve resistance is the resistance offered by a curve to the progress of a train. No complete satisfactory theoretical discussion of CR has been published. However, engineers in the US usually allow from 0.8 to 1 pound per ton of train per degree of curve. In military railway planning, use the factor of 0.8 pounds multiplied by the degree of curvature.

Table 10-1. Safe Average Values

Track Condition	Average Value
Exceptionally good	5
Good to fair	6
Fair to poor	7
Poor	8
Very poor	9 and 10

WEATHER FACTOR

10-14. The weather factor reflects, by percentage, the adverse effect of cold and wet weather on the hauling power of a locomotive. Experience and tests has proven that whenever the outside temperature drops below 32 degrees Fahrenheit, the hauling power of a locomotive is decreased. Table 10-2, page 10-8, shows the weather factor (percent) for varying degrees of temperature.

10-15. Wet weather is usually regarded as local and temporary and is considered absorbed by average figures. However, in countries having extended wet seasons (monsoons, fog, and so forth), the loss of tractive effort due to slippery rails may prove serious if sanding facilities are lacking or inadequate. The applicable reduction is a matter of judgment. However, in general, tractive effort will not be reduced to less than 20 percent of the weight on drivers.

Table 10-2. Effect of Weather Upon Hauling Power of Locomotives

Most adverse temperature (°F)	Loss in hauling power (percent)	Weather factor (percent)
Above +32	0	100
+16 to +32	5	95
0 to +15	10	90
-1 to -10	15	85
-11 to -20	20	80
-21 to -25	25	75
-26 to -30	30	70
-31 to -35	35	65
-36 to -40	40	60
-41 to -45	45	55
-46 to -50	50	50

GROSS TRAILING LOAD

10-16. Gross trailing load is the maximum tonnage that a locomotive can move under given conditions (for example, curvature, grade, and weather). When diesel-electric locomotives are operated in a multiple unit operation, the GTL is equal to the sum of the GTL for all locomotives used. However, when the locomotives are not electrically connected for multiple unit operation, deduct 10 percent of the total GTL for the human element involved. Determine GTL by combining the factors discussed in the preceding paragraphs and using the following formula:

$$GTL = \frac{DBP \text{ X } WF}{RR + GS + CR}$$

Where–

GTL = gross trailing load

DBP = drawbar pull

WF = weather factor

RR = rolling resistance

GR = grade resistance

CR = curve resistance

10-17. Obtain the GTL by actual test for foreign or captured locomotives (for which little or no information is available) as quickly as track and cars become available.

NET TRAINLOAD

10-18. Net trainload is the payload carried by the train. The total weight of the cars under load is gross weight. The lightweight, or weight of empty cars, is tare. The difference between gross weight and tare is the NTL (payload) of the train. For military railway planning purposes, the NTL is 50 percent of the GTL. The formula is computed as follows: NTL = GTL X .50.

TRAIN DENSITY

10-19. The number of trains that may be operated safely over a division in each direction during a 24-hour period is known as train density. Work trains are not included in computing TD. However, their presence on divisions and the amount of time they block the main track can reduce the density of a rail division. TD may vary greatly over various divisions depending on the following:

- Condition and length of the main line.
- Number and locations of passing tracks.
- Yard and terminal facilities.
- Train movement control facilities and procedures.
- Availability of train crews, motive power, and rolling stock.

10-20. On single-track lines, passing tracks generally are 6 to 8 miles (10 to 13 kilometers) apart. Multiple tracks (three or more) generally are considered as double track, since it is often necessary to remove a portion or all of the third and fourth tracks to maintain a double-track line.

10-21. The capacity or operating turnover of cars and trains into and out of terminal yards must be considered, either from definite experience and intelligence factors or by inference from related information.

10-22. The rule-of-thumb and the formula for determining single track are designed primarily to determine freight train density. Both are reasonably accurate on lines over which passenger trains do not exceed 20 percent of the traffic.

Rule-of-Thumb for Determining Train Density

10-23. If enough information is not available to evaluate the potential train density of a rail line, a train density of 10 for single track and 15 for double track in each direction is used for planning.

Formula for Determining Single Track

10-24. If enough information is available, the following formula is used to determine train density for a specified railway division. In determining the number of passing tracks, do not include those less than 5 miles (8 kilometers) apart. Passing tracks should be uniformly spaced throughout the division.

$$TD = \frac{NPT + 1}{2} \quad X \quad \frac{24 \times S\ 2}{LD}$$

Where–

TD = train density.

NPT = number of passing tracks.

1 = constant (number of trains that could be run if there were no passing tracks).

2 = constant to convert to each direction.

24 = constant (number of hours per day).

S= average speed (Table 10-3).

LD = length of division.

When the computation for train density results in a fraction, the result is raised to the next higher whole number.

NET DIVISION TONNAGE

10-25. Net division tonnage is the tonnage in STONs, or payload, which can be moved over a railway division each day. NDT includes railway operating supplies that must be programmed for movement. The formula for NDT is: NDT = NTL X TD. Compute NDT separately for each division.

END DELIVERY TONNAGE

10-26. In military operations, the end delivery tonnage is the through tonnage, in STONs, of payload that may be delivered at the end of the railway line (railhead) each day. In an all-rail movement, the EDT equals the NDT of the most restrictive division.

Table 10-3. Determining Average Speed Value

Condition of track	Percent of grade	Average speed: Single track (mph)	(kph)	Double track (mph)	(kph)
Exceptionally good	1.0% or less	12	19.3	14	22.5
Good to fair	1.5% or less	10	16.1	12	19.3
Fair to poor	2.5% or less	8	12.9	10	16.1
Poor	3.0% or less	6	9.6	8	12.9

Notes:

1. The most restrictive factor governs the speed selected.

2. Consider the following, when using the table for average speed factor.

a. If the condition of track and/or the percent of grade are not known, use an average speed value of 8 MPH for single track and 10 MPH for double track.

b. Where the most restrictive factor occurs for a comparatively short distance--that is, less than10 percent of the division--use the next higher speed.

c. Where average speed falls below 6 MPH because of the grade lines, reduce the tonnage to increase speed (2 percent reduction in gross tonnage will increase speed 1 MPH).

YARD CAPACITY DETERMINATION

10-27. The capacity of the yard needs to be determined based on planning factors and planning formulas. The following describes the planning factors and planning formulas for classification yards. Also described below are the planning factors for terminals with and without receiving and forwarding yards.

PLANNING FACTORS FOR CLASSIFICATION YARDS

10-28. The following factors are based on day and night operations and may be used for planning purposes. Where two or more main line railways intersect at a major terminal, the facilities will have to be duplicated accordingly.

10-29. Flat switching capacity is 30 cars per locomotive per hour. This includes time for switch engines to push cars into the yard (based on foreign equipment). Hump switching capacity is 45 cars per locomotive per hour.

10-30. The numbers of cars, at any given time, in a classification yard should not exceed 60 percent of the yard's capacity. When cars exceed yard capacity, switching room decreases and operating efficiency is sacrificed.

10-31. Length of track in a classification yard generally is one train length, plus 20 percent, plus 300 feet (91 meters). Track and/or train length varies with local terrain characteristics and railway equipment and requirements.

10-32. Depending on the yard layout, the number of switch engines per shift that may be employed in the operation of the loaded freight classification yard may vary from one to three. Therefore, one switch engine may handle 30 to 60 cars per hour and three switch engines may handle 90 to 180 cars per hour. Functions for switch engines include the following:

- One switch engine at the head of the receiving yard, preparing cut of cars for switching.
- One switch engine switching cut of cars into the classification yard.
- One switch engine at the opposite end of the classification yard, coupling cars and making switching room.

During slack traffic periods, one switch engine may be used for all functions above. The switch engine functions above are also used in the classification yard proper and do not include those engaged in supporting other terminal operations.

10-33. The average time a car remains in the classification yard is 8 hours. Classification yard traffic changes an average of three times per day. (Some cars may be held 48 hours; others may clear in less than 8 hours.)

PLANNING FORMULAS FOR CLASSIFICATION YARDS

10-34. You may use the following formulas to determine classification yard requirements and capabilities.

- Determine the required length of yard tracks using the following:

  LT = ACT X LC X 1.2
  + 300 feet (91 meters)

Where–

LT =	length of track.
ACT =	average cars per train.
LC =	average length of car.
1.2 =	operational factor (to allow for overall length of car coupler rather than car length).
300 feet =	clearance distance at each end of track from point of switch to clearance.

- Determine the minimum number of tracks using the following:

$$NTR = \frac{TDs}{3} \times 1.6$$

Where–

NTR = number of tracks required.

TDs = sum of train densities of using divisions.

3 = turnover per day.

1.6 = 60-percent factor of static capacity.

When computing requirements for a terminal yard, the result obtained in this formula must be doubled. The formula does not necessarily apply to railheads since classification of cars is not always necessary at railheads.

- Determine static yard capacity using the following:

$$SYC = ACT \times NT$$

Where–

SYC = static yard capacity (in cars).

ACT = average cars per train.

NT = number of tracks of the length determined in paragraph 10-34, first bullet.

Daily yard capacity is equal to 1.6 times SYC. This figure takes into account that the number of cars in a yard at any given time will not exceed 60 percent of the static capacity.

PLANNING FACTORS FOR TERMINALS WITH AND WITHOUT RECEIVING AND FORWARDING YARDS

10-35. The following factors are based on how trains are moved in the terminal. These factors may be used for planning purposes.

With Receiving and Forwarding Yards

10-36. Where trains are operated into and out of terminals at 48-minute intervals, there should be a minimum of six tracks plus one runaround track in both the receiving and forwarding train yards to handle empty and loaded trains. In general, the number of tracks required equals the train density divided by 5, plus 1.

$$NT = \frac{TD}{5} + 1$$

Without Receiving and Forwarding Yards

10-37. Normally, receiving and forwarding train yards will be in balance with classification and main line capacity. However, some railways dispense with receiving and forwarding yards and operate all trains directly into and out of classification yards. In such cases, the classification yard's daily capacity is reduced by approximately 25 percent.

Two-Wall Tonnage Traffic in Terminals

10-38. Where there is two-way tonnage traffic in large terminals, the various yards are normally designed with yards for each direction. For example, northbound receiving, classification; forwarding yards and southbound receiving, classification; and forwarding yards.

RAILWAY EQUIPMENT REQUIREMENTS

10-39. Availability of equipment in liberated or occupied territory depends upon inventories, extent of destruction, condition of equipment, types of fuel and local availability of repair parts, types of coupling devices, and many other such factors. Base allowances, for use of captured or locally available equipment, on judgment after evaluation of the many factors involved. Technical data concerning railway equipment may be found in strategic surveys, special transportation studies based on intelligence reports, reports of governments or railways in peacetime, and sometimes in publications such as Railway Gazette (British) and Railway Age (American). The categories of equipment requirements considered when planning are as follows:

- Rolling stock, consisting of boxcars, gondolas, flatcars, tank cars, refrigerator cars, and hopper cars.
- Road engines, the motive power used to pull trains between terminals or division points.
- Switch engines, the motive power used to switch cars within yards or at division terminals.

Step-by-step procedures for determining railway equipment requirements are given in Appendix B.

ROLLING STOCK

10-40. There are three classes of railway rolling stock. These classes consist of freight, passenger, and special.

Freight

10-41. Compute requirements separately for operations between major supply installations or areas on each rail system. Use the following formula to compute requirements.

$$\text{Total cars Required} = \frac{\text{EDT (by type car)}}{\text{Average payload for type car}} \times \text{TAT} \times 1.1$$

Where–

EDT = end delivery tonnage.

TAT = turnaround time.

10-42. Obtain the first factor of this formula from that part of the computation for 1 day's dispatch which determines the number of cars required by type to transport all or a given portion of the EDT of a rail system (see Appendix B, third computation).

$$1\ DD = \frac{\text{EDT (by type car)}}{\text{Average payload for type car}}$$

10-43. The number of cars dispatched in a day from the base of operations is 1 day's dispatch. For planning purposes, the number of cars dispatched from a division terminal, railhead, or other dispatch point is considered the same as the number dispatched from the base of operations. Use the formula shown in paragraph 10-42 to determine the rolling stock for 1 day's dispatch. Computations are made for each type of car to be used (boxcars, gondolas, and/or flatcars) and the sum of the results for all types of cars that are computed are 1 day's dispatch for the system (see Appendix B, third computation).

10-44. Turnaround time is the estimated number of days required for a car to make a complete circuit of the rail system. It is the days elapsed from the time the car is placed at the point of origin for loading until it is moved to its destination, unloaded, and returned to its point of origin. Time may be computed as follows: 2 days at origin, 1 day at destination, and 2 days in transit (1 day forward movement, 1 day return movement) for each division or major portion of each division which the cars must traverse. This method, rather than an actual hour basis, is used to incorporate delays due to terminal and way station switching as well as in-transit rehandling of trains.

10-45. The 1.1 factor is used to express a 10-percent reserve factor. The reserve factor provides for extra cars to meet operational peaks, commitments for certain classes of cars, and bad-order cars (cars needing repair).

10-46. Compute planning factors for net load per freight cars by using 50 percent of the rated capacity for all freight cars except tank cars. Tank cars are rated as carrying 100 percent of their capacity.

10-47. Compute tank car requirements separately based on bulk POL requirements, tank car capacities, and computed turnaround time. The disposition of rolling stock for the operation of a railway system is shown in Table 10-4, page 10-16.

Table 10-4. Disposition of Rolling Stock

Disposition	**Rolling Stock Required**
At base of operation	2 day's dispatch
Forward traffic	1 day's dispatch per division
Return traffic	1 day's dispatch per division
At the railhead	1 day's dispatch

Passenger

10-48. Passenger car requirements vary depending on troop movement policies, evacuation policies, and rest and recuperation policies. Theater passenger car requirements normally are fulfilled by acquisition of local equipment with the exception of equipment required for hospital cars or trains.

Special

10-49. Special equipment is that equipment used exclusively by the railroad for its own use. This type of equipment includes maintenance of way equipment, work cranes, snow removal equipment, locomotives, and so forth.

ROAD ENGINES

10-50. You may determine the number of road engines required for operation over a given railway division by the following formula:

$$\text{Road engines Required} = TD \times \frac{(RT + TT)}{24} = \; X \; 2 \; X \; 1.2$$

Where–

TD = train density.

RT = running time (length of division divided by average speed).

TT = terminal time (time for servicing and turning locomotive is 3 hours for diesel-electric locomotives and 8 hours for steam locomotives).

24 = number of hours per day.

2 = constant for two-way traffic.

1.2 = constant allowing 20-percent reserve.

$\frac{(RT + TT)}{24}$ = engine factor (time during a 24-hour period in which a road engine is in service). The engine factor provides for motive power, which may make more than one trip per day over a short division.

Switch Engines

10-51. No two ports, divisions, or terminal railheads are alike in design or operation. However, the functions of the main yards in each are essentially the same. Receiving cars, classifying, and reassembling them for delivery or forward movement constitutes the main functions of any yard. The switch engine is the type of motive power used for these operations.

10-52. The number of switch engines required at a terminal is based on the number of cars dispatched and received at, or passing through, the terminal per day. When the number of cars has been computed, apply that figure to the factors shown in Table 10-5 to determine the number of switch engines required at each terminal.

10-53. When the total number of switch engines required for the railway line has been computed, 20 percent is added as a reserve to allow for maintenance, operational peaks, and so forth (see Appendix B, fourth computation).

Table 10-5. Switch Engines Required

Location	Switch Engines Required
Port or loading terminal	1 per 67 cars dispatched and received per day
Division terminals	1 per 100 cars passing per day
Railhead or unloading terminals	per 67 cars dispatched and received per day

PERSONNEL AND UNIT REQUIREMENTS

10-54. Requirements for rail units and personnel are based on the following:

- Number of divisions in the system. This provides a guide in determining the number of battalions required for operation.
- Number of train operating crews required to operate road and switch engines. This provides a guide to determine the number of train operating companies required in the system.
- Maintenance requirements for right-of-way, locomotives, and rolling stock. This provides a guide to determine the number and type of maintenance units and personnel required.

On the basis of these factors, you can use unit and organizational capabilities and normal employment procedures to organize a command structure and to determine support requirements.

ROAD CREWS

10-55. In computing the number of road crews required for each division, preparation time is included. Preparation includes the following:

- A 2-hour period at the originating terminal for the crew to receive orders and instructions, test the air, and check the train.
- Running time involved, which is computed by dividing the length of the division by the average speed of the train. If information is not available to compute the speed, the speed may be assumed to be 10 miles per hour. Normally, running time over a division will be about 12 hours.
- A 1-hour period at the final terminal to submit necessary reports.

10-56. To allow enough time for the crews to rest, the running time normally does not exceed 12 hours. Although experience shows that safety and efficiency decrease when crews work continuous daily shifts of more than 12 hours, this time can be exceeded in emergencies. However, it is possible to work shifts of 16 to 18 hours, if the crews have enough rest periods before reporting for another run. Sometimes it will be necessary to designate longer hours because of the length of the division involved. In such cases, enough time off between runs should be permitted to limit the average daily shift to 12 hours.

10-57. When determining the number of road crews needed per division use the following formula (see fifth computation, Appendix B).

$$\text{Number of road crews} = TD \times 2 \times \frac{(RT + 3)}{12} \times 1.25$$

Where–

TD = train density.

2 = factor to convert to two-way traffic.

RT = running time (length of division divided by average speed).

3 = 2 hours allowed for preparation at originating terminal, plus 1 hour at final terminal.

12 = 12-hour shift per road crew per day.

1.25 = constant factor to allow for ineffectives.

SWITCH CREWS

10-58. To determine the number of switch crews required, the number of switch engines in use at each terminal must be known. Two crews are required per switch engine per day. Use the following formula to determine the number of switch crews required for each terminal (do not compute crews for reserve switch engines) (see fifth computation. Appendix B):

Number of switch crews = SE X 2 X 1.25.

Where–

SE = number of switch engines.

2 = crews per engine.

1.25 = constant factor to allow for ineffectives.

SUPPLY REQUIREMENTS

10-59. Railway supply tonnages are normally quite large. Planners, when computing EDT, should ensure that all concerned persons understand that supply tonnage must be deducted from EDT to arrive at the actual figure that will be delivered to the units at the railhead. The following paragraphs discuss the method of arriving at specific supply requirements for fuel, lubricants, and repair parts.

FUEL CONSUMPTION OF DIESEL-ELECTRIC LOCOMOTIVES

10-60. Table 10-6, page 10-20, contains an estimated average rate of diesel fuel oil consumption in gallons per train-mile for diesel-electric road locomotives and in gallons per hour of operation for switch engines. For planning purposes, the operation of switch engines is assumed to be 20 hours per day. The method of determining fuel oil requirements in gallons for road locomotives and switch engines is as follows:

10-61. The following is the method of determining fuel oil requirements, in gallons, for road locomotives:

- Multiply the train density of the first division by 2 (for two-way travel), then multiply the result by the length of the division. This result is the train-miles per day for the division.
- Repeat this procedure for each division of the system.
- Total the daily train-miles for all divisions.
- Multiply the total daily train-miles by the fuel consumption factor to obtain the daily fuel requirement.
- Multiply the daily fuel requirement by 30 to obtain the monthly fuel requirement.
- Add 5 percent to this computed total to provide a reserve for contingencies.

Table 10-6. Fuel Requirements for Diesel-Electric Locomotives

Type of Locomotive	Type of Operation	Estimated Average Rate of Fuel Oil Consumption: Gallons Per Train-Mile	Gallons Per Hour
*Standard gauge:			
0-6-6-0, 120-ton	Road switcher	2.5	11.5
0-4-4-0, 50-ton	Road switcher	.9	8.0
*Narrow gauge:			
0-6-6-0, 80-ton	Road switcher	1.5	10.0
0-4-4-0, 48-ton	Road switcher	.9	8.0
*When computing fuel requirements and the table does not provide for an engine wheel match and/or tonnage match, the next largest wheel/tonnage figure should be used.			

10-62. The following is the method of determining fuel oil requirements, in gallons, for switch engines:

- Multiply the total number of switch engines required (do not include reserve engines) by 20 to determine the total hours per train-day of operation.
- Multiply the total hours per train-day of operation by the fuel consumption factor of the engine concerned (Table 10-3). This result is the daily fuel requirement in gallons.
- Multiply the daily fuel requirement by 30 to obtain the monthly fuel requirement.
- Add 5 percent to this computed total to provide a reserve for contingencies. When coal is the fuel, use a reserve factor of 10 percent.

LUBRICANTS

10-63. Use lubricants on all moving parts of railway tools, appliances, machinery; and on all motive power and rolling stock. For planning purposes however, only the lubricants necessary for the operation of motive power and rolling stock are based on an estimate of 1,000 pounds per month for each train moving in either direction over each division in one day. Use the following method to determine the amount of lubricants required:

- Multiply the train density of the first division by 2 (for two-way travel); then multiply the result by 1,000. This gives the amount in pounds of lubricants required per month for the division.

- Repeat this procedure for each division of the system.
- Total the amount of lubricants for all divisions to determine the grand total of STONs required per month for the railroad.

REPAIR PARTS

10-64. In a theater, the number and kinds of supplies and repair parts are seldom found necessary to maintain the motive power and the rolling stock used by the unit. For planning purposes, only the repair parts necessary for the maintenance of motive power and rolling stock are considered. An estimate of repair parts required is based on a factor of 1.5 STONs per month for each train moving in either direction over each division in one day. Use the following method to determine repair parts required:

- Multiply the train density of the first division by 2 (for two-way travel). Multiply the result by 1.5 to get the total amount in STONs of repair parts required per month for the division.
- Repeat this procedure for each successive division of the system.
- Total the amounts to determine the grand total of STONs required per month for the entire railroad.

10-65. Good judgment and certain assumptions are required when making allowances for railway operating supplies. It is assumed that all trains operated over each division are tonnage trains and that each division requires the same amount of operating supplies. The above formulas are an accepted method for computing operating supplies from a broad spectrum; however, a more refined method would employ the following methodology in making allowances:

- **First division.** No allowance is made, since the operating supplies are available at the port terminal or base of operations.
- **Second division.** An allowance of 5 percent of the first division net tonnage, which means only 95 percent of the first division net tonnage, will be hauled over the second division.
- **Third division.** An additional allowance of 5 percent of the first division net tonnage, or a total deduction of 10 percent of the first division net tonnage, which leaves only 90 percent of the original tonnage to be hauled over the third division.
- **Additional division.** An additional allowance of 5 percent of the first division net tonnage will be made for each successive division, with a corresponding reduction in tonnage hauled.