Rail Gauge Logistical Challenges in 21st Century Rapid Deployment and Reinforcement

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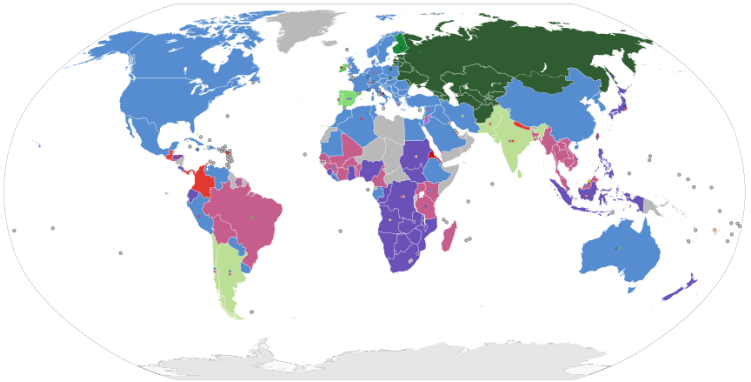
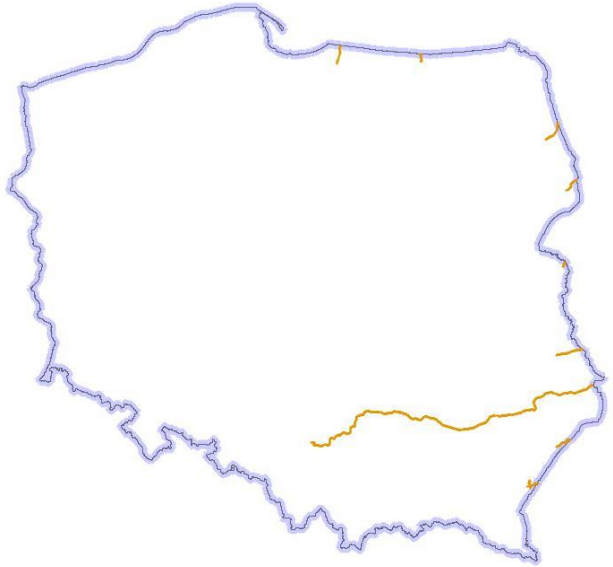
The Challenge

- Most of the world uses a standard rail gauge of 1,435mm
- Russia and other former Soviet countries use a broad 1,520mm rail gauge
- Most long-distance ground transport of military equipment is dependent upon rail transport
- Since a potential conflict on NATO's eastern flank most likely will close the Baltic and Black Seas to transport, rail will be critical to sustaining a NATO defense of the Baltic States or a hypothetical defense of Ukraine



A Serious Complication?

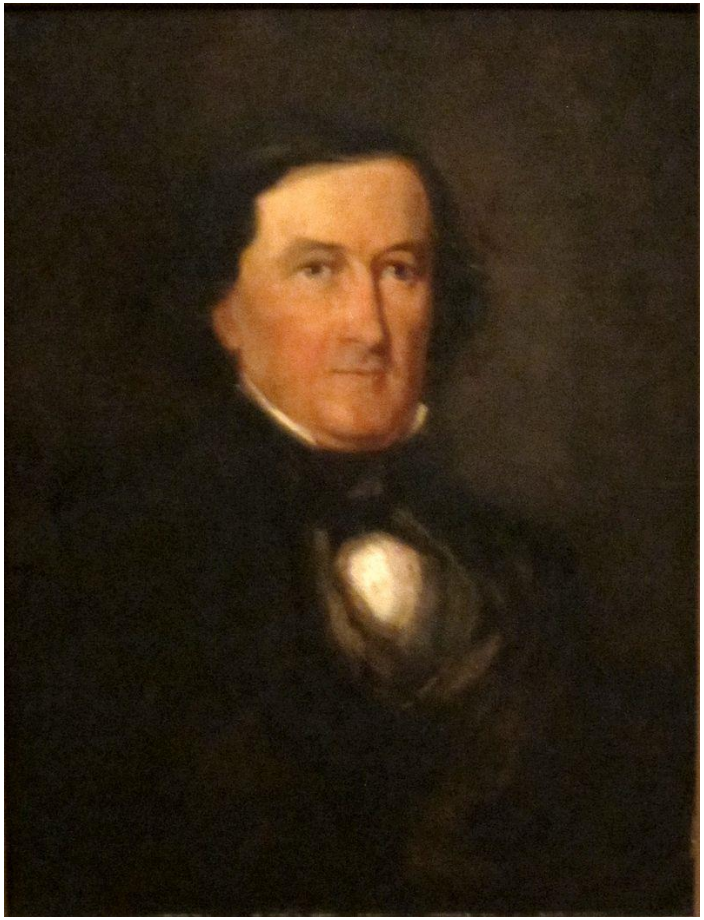


- The rail gauge interchange is not an unsurmountable logistical challenge, but it does pose complications for deployment times
- The historical record for overcoming different rail gauges during warfare is very long
- This presentation examines the historical record and weighs options for best bridging the gap

A History of the Russian Rail Gauge

A Tsarist Experiment

- In 1839, Tsar Nicholas I's chief railroad engineer invited Whistler's father to Russia to design the Moscow-St. Petersburg rail line
- American industrialist George Washington Whistler created the Russian 1,520mm rail gauge to increase the speed and stability of trains over the European standard
- The Moscow-St. Petersburg line, the first of this gauge and at the time the longest double-tracked rail line in the world, was opened in 1851
- Its inaugural trip traveled at a speed of 19.5 km/h

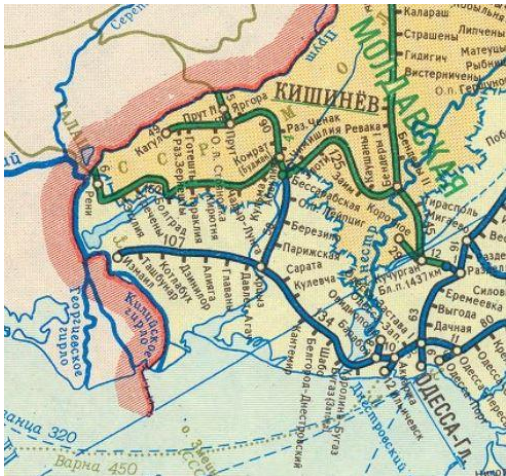


Rail Gauge in War

- The first major test of rail sustainment in war was the Franco-Prussian War
- The hub-and-spoke model of French railway development made rapid movement of troops through the theater difficult
- The Prussian Army therefore engaged in considerable rail line construction in war
- The Prussians, and most other Westerners, concluded that narrow-gauge rail lines would be more useful during wars due to their cost effectiveness, the rapidity with which they could be laid, and the ease with which they could be moved in the event of a change in the FLOT

Russo-Turkish War of 1877-1878

- The Russian Empire established its Railway Troops (*Железнодорожные войска*) to sustain rail logistics in the Balkans
- Underdevelopment of narrower-gauge railways in Romania and poor maintenance of the rail lines in Russian Moldavia placed extreme limits on Russian forces deployed against the Ottoman Empire
- Against European expectations, Russia laid 305km of broad-gauge railway in 100 days (of which, only 58 could be used due to inclement weather)
- This represents a track-laying rate of 5.3km per day
- The line was retained after the war and remained a key part of the Tsarist/Soviet rail network
- This marks the start of one of Russia's strategies for overcoming a rail gauge difference: building its own network during wartime

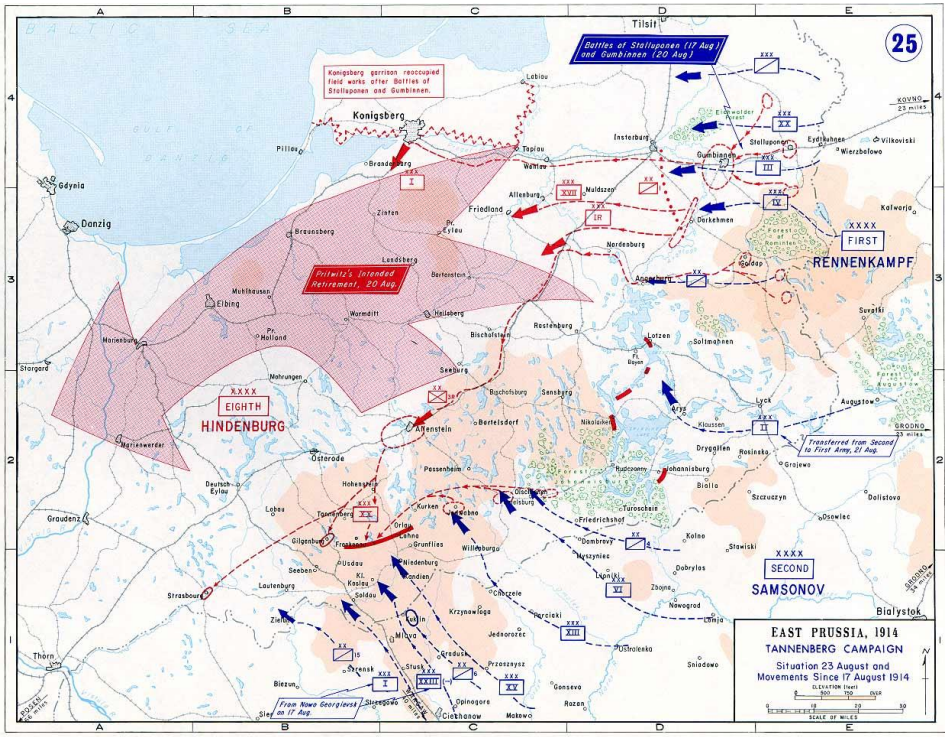


Late Tsarist Rail Development

- Russian victory in 1879 confirmed the use of broad-gauge rail in wartime to the Tsarist government
- In the 1880s, the central government began a centralized program overseeing the strategic development of an empire-wide railway program modeled on the simultaneous development of the United States
- 1890-1904: construction of the Trans-Siberian Railway at a rate of 1.506km of track per day (increased at the end by the necessity of the Russo-Japanese War) by 12 BGE equivalents
- 1890-1904: Construction of track at a regularized rate of 0.1255 km/day/BGE
- Defeat in the Russo-Japanese War, partially because of the limited traffic capabilities of the single Trans-Siberian rail line, inspired a Russian General Staff-directed rail improvement program from 1907 to 1914
- Despite greater attention given, this initiative produced 10,187km total of track in that time (3.6776 km per day)
- However, this work was conducted with 29 railway BGE equivalents, giving an average rate of just 0.1268 km/day/BGE

First World War: Phase 1: AUG 1914 – JUN 1915

- In AUG 1914, France demanded Russia launch a summer offensive against the German Empire to relieve the pressures it faced before the Battle of the Marne
- The Russian Empire duly invaded East Prussia, but its progress was massively delayed by:
    1. Incomplete Russian mobilization
    2. The process of switching the rail gauges from standard- to broad-gauge track by wholesale laying of a new rail network
- German freedom of maneuver enabled their own rail redeployments to enable overwhelming victories at Tannenberg and the Masurian Lakes



First World War: Phase 1: AUG 1914 – JUN 1915

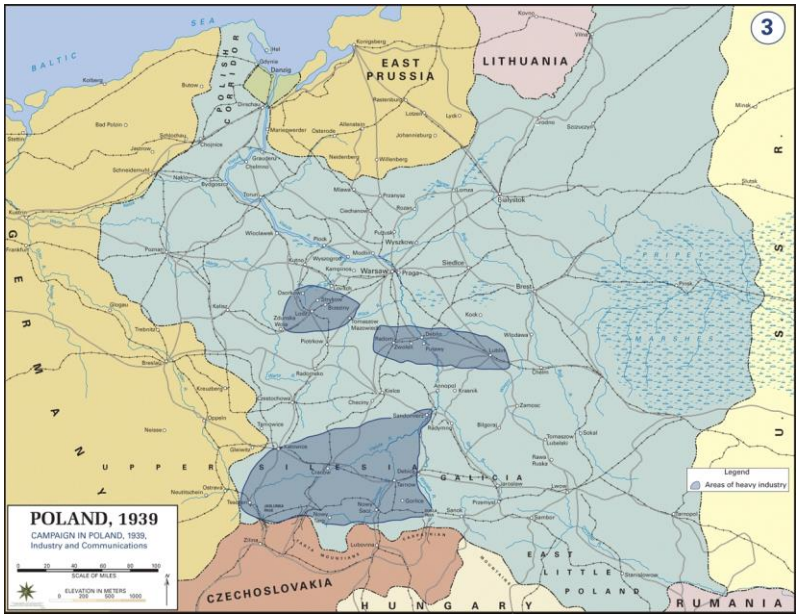
- After the catastrophe in Prussia, Russian efforts were concentrated against Austria-Hungary
- This required constant movement of mobilization forces into the Warsaw Military District, overwhelming first the Railway troops and then the Tsarist Ministry of Railways
- This was further complicated by the existence of considerable standard-gauge rail in prewar Tsarist Poland
- 3,900km of rail was broad-gauge laid during this period under the organization of 8 BGE equivalents
- 1.6142 km/day/BGE
- Because of the enormous movement of manpower, only one track of double-tracked rail sections were restored

First World War: Phase 2: JUN 1915 – MAR 1917

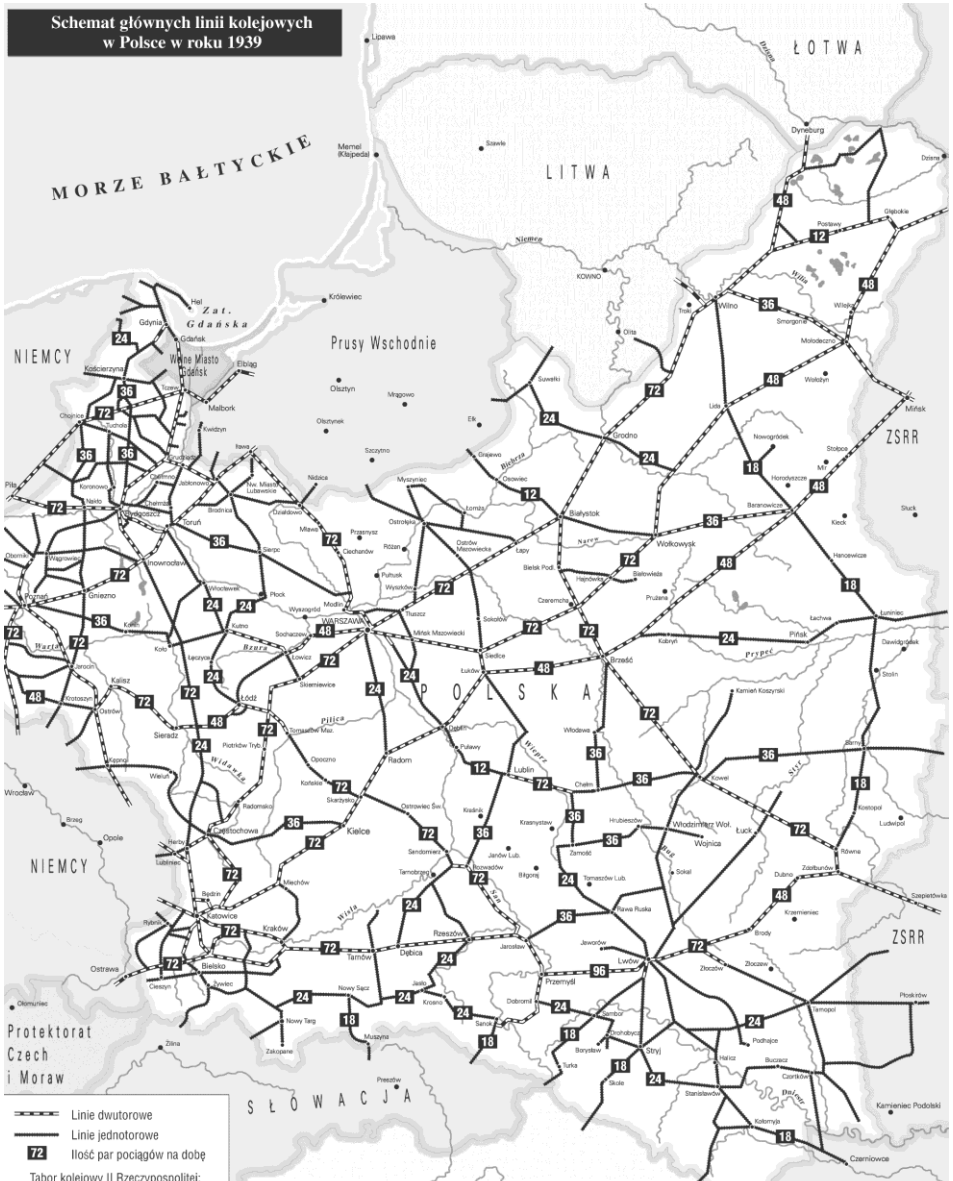
- After defeat in the Gorlice-Tarnow Offensive, the Eastern Front stabilized along a line that mostly held through the February Revolution
- During this stasis, Russian logistics were helped by the shortened lines and consistent rail gauge from the rear
- Logistical difficulties in this period were most marked in the declining availability of rolling stock than of dilapidated track
- By this time, the Railway Troops had reached a strength of 133,000 in 8 units (each unit a WWI-sized division)

Interwar Years

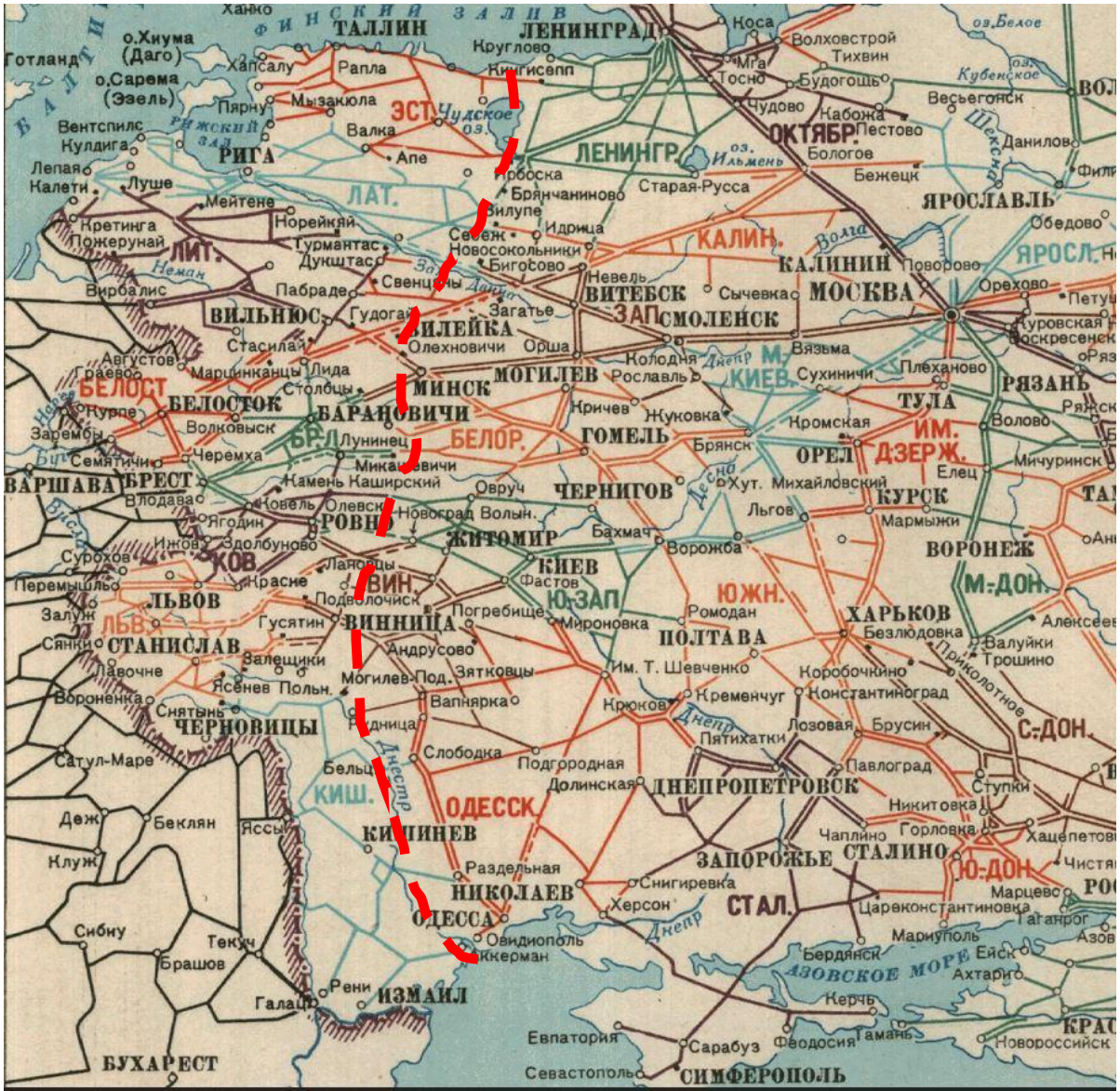
- The Russian Civil War featured few rail gauge transfers
- During the interwar years, Poland's eastern border was considerably further east than it is today
- Within that space, including much of western Belarus and Ukraine, standard-gauge 1,435mm rail was built



Interwar Years



Soviet Rail after Molotov-Rippentrop



Second World War (Great Patriotic War)

- For the first half of Soviet involvement, the war was fought in Soviet territory on Russian broad-gauge rail
- Owing to the paucity of Soviet rail lines in general, it was easy for the lines to be destroyed as the Soviets retreated and so the Germans built standard-gauge rail to sustain their operations
- As the Soviets returned westward, they too built their own rail lines
- Over the entire war, the Soviets laid 10,000km of new broad-gauge track and restored 120,000km
- This would collectively amount to 94km/day, but stretched across an especially large number of formations
- One specially recognized railway brigade singly laid 5,063km of broad-gauge track over the course of the war
- This specially-cited-for-praise brigade therefore laid an average of 3.67km/day under circumstances of total mobilization

A New Problem

- The first broad-gauge rail line to Berlin was completed on 07 MAY 1945, one day before the end of the war
- After the war, the Red Army's function shifted toward packing and shipping confiscated German industry back to the Soviet Union
- Meanwhile, the Soviet government turned logistical planning toward demobilization and domestic reconstruction, leading to a steady degradation of broad-gauge rail lines beyond Soviet borders under the constant strange of disassembled German factories
- When the prospect of a future conflict in Europe with the West emerged in 1946, the Soviet Union had both a problem and an opportunity:
  - It might need to rapidly redeploy units westward
  - But substantial Red Army echelons and puppet governments now controlled substantial depth beyond the edge of the established Soviet rail network

Rail Gauge Transfer

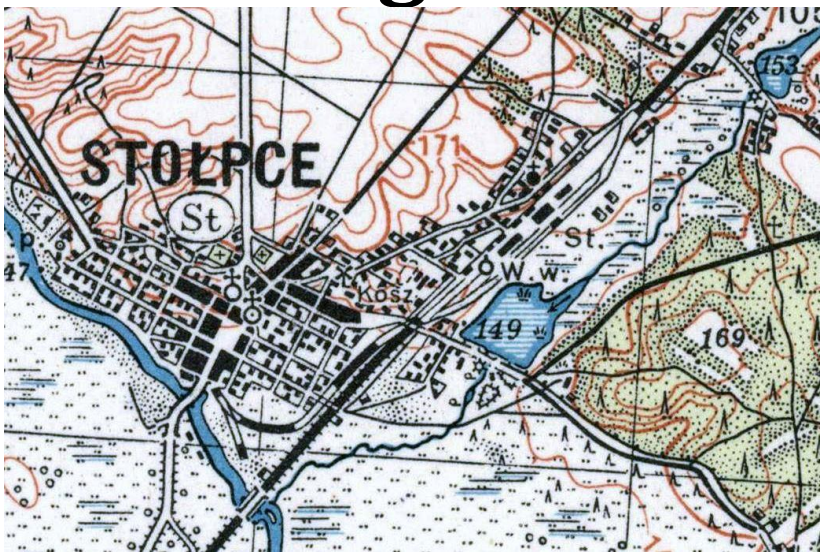


Рис. 1. Схема узловой станции Г.

- In the late 1940s, Soviet Railway Troops began improving inter-rail gauge node stations to increase total available capacity
- By laying additional track sidings parallel to alternative gauge track, rail schedules could be kept at mobilized rates while only taking the time to do a single freight transfer

Rail Gauge Transfer

- By laying this track on a very large scale, the Soviet Union was ultimately able to produce far more rail gauge transfer nodes than could be used simultaneously
- By coordinating rail car movement so as to prevent overloading of any particular station, the Soviet General Staff reasoned that these nodes would only cause an initial delay and would subsequently be a continuous process of loading and reloading

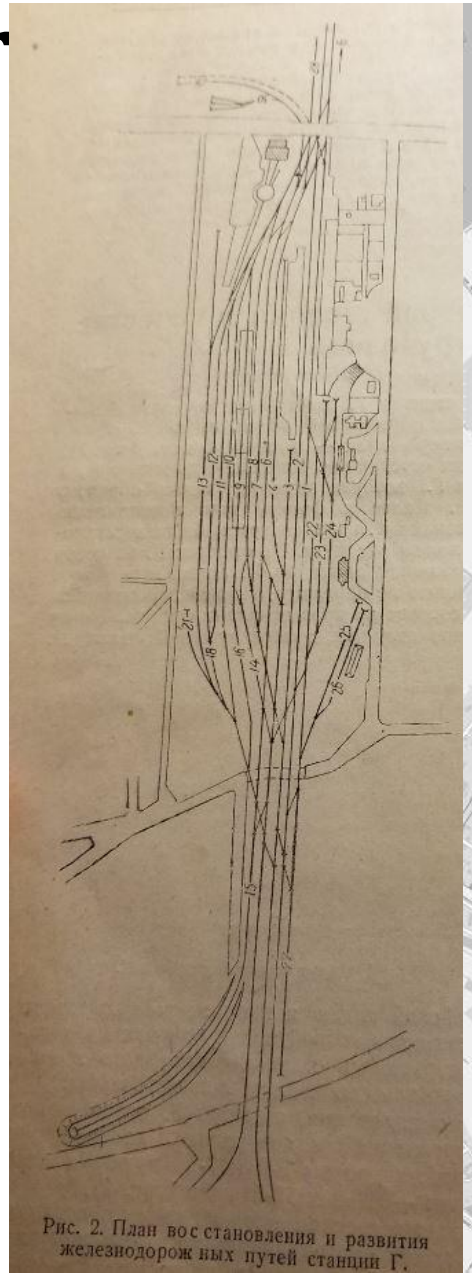
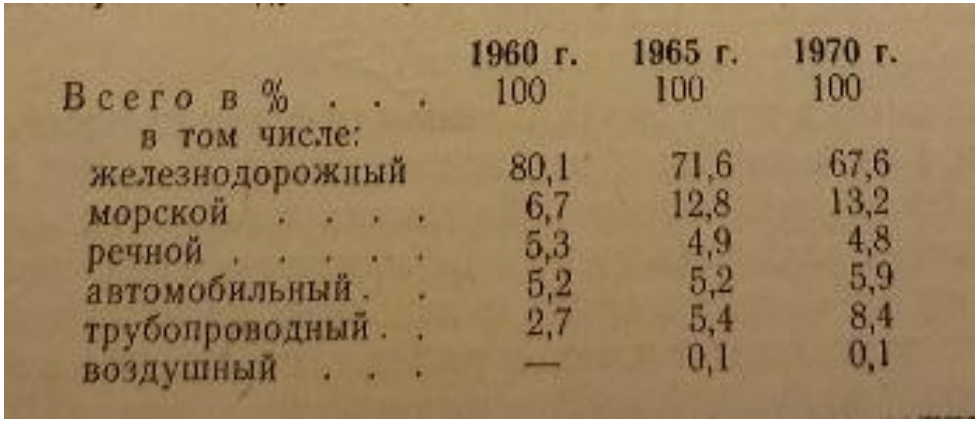


Рис. 2. План восстановления и развития железнодорожных путей станции Г.

Cold War

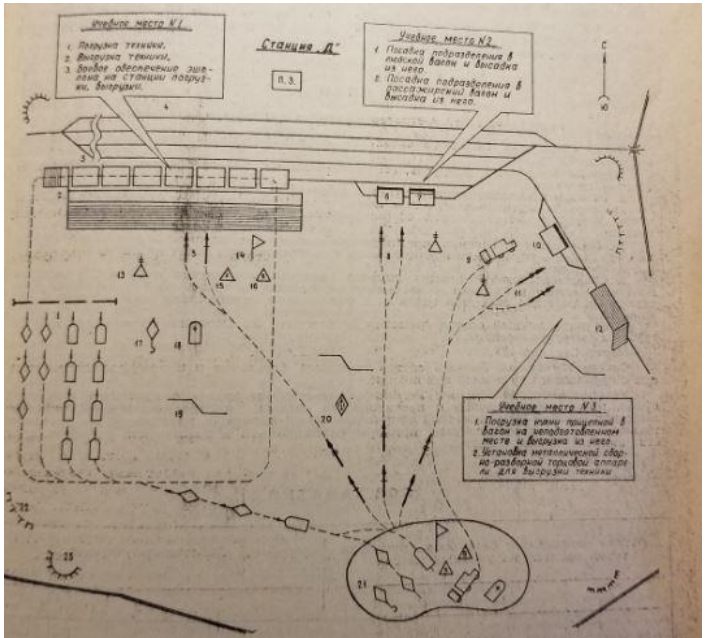
- Two options now existed for the Soviet Union to transport units to the European front during the Cold War:
  - Building new broad-gauge rail networks both before and during wartime
  - Transferring items between trains at a gauge-transfer node station
- Soviet efforts to electrify its internal rail lines and motorize its troops prevented investment in standardizing rail lines across the Warsaw Pact
- The Soviet General Staff officially maintained that individual military district/TVD commanders should work to construct broad-gauge rail during the equivalent of “Shape” phase
- De facto, this was rarely ever done



	1960 г.	1965 г.	1970 г.
Всего в %	100	100	100
в том числе:			
железнодорожный	80,1	71,6	67,6
морской	6,7	12,8	13,2
речной	5,3	4,9	4,8
автомобильный	5,2	5,2	5,9
трубопроводный	2,7	5,4	8,4
воздушный	—	0,1	0,1

Cold War

- In 1977, official doctrine taught to the Soviet General Staff held that two railway brigades could collectively build 30-45 km of broad-gauge track per day
- After employment of weapons of mass destruction, this rate would halve
- In 1971, the CIA assessed that the initial anticipated delay in conducting a rail transfer deployment operation would require 7 hours



Logistical Depth Questions

- Soviet logisticians held that lift materiel could be transported into combat operations from a depth of up to 1800-2000km within *TVD* command
- However, they should only be offloaded from trains at most 50km from their respective operational jump-off point
- This reflects a great decrease from historical standards

Logistical Depth Questions

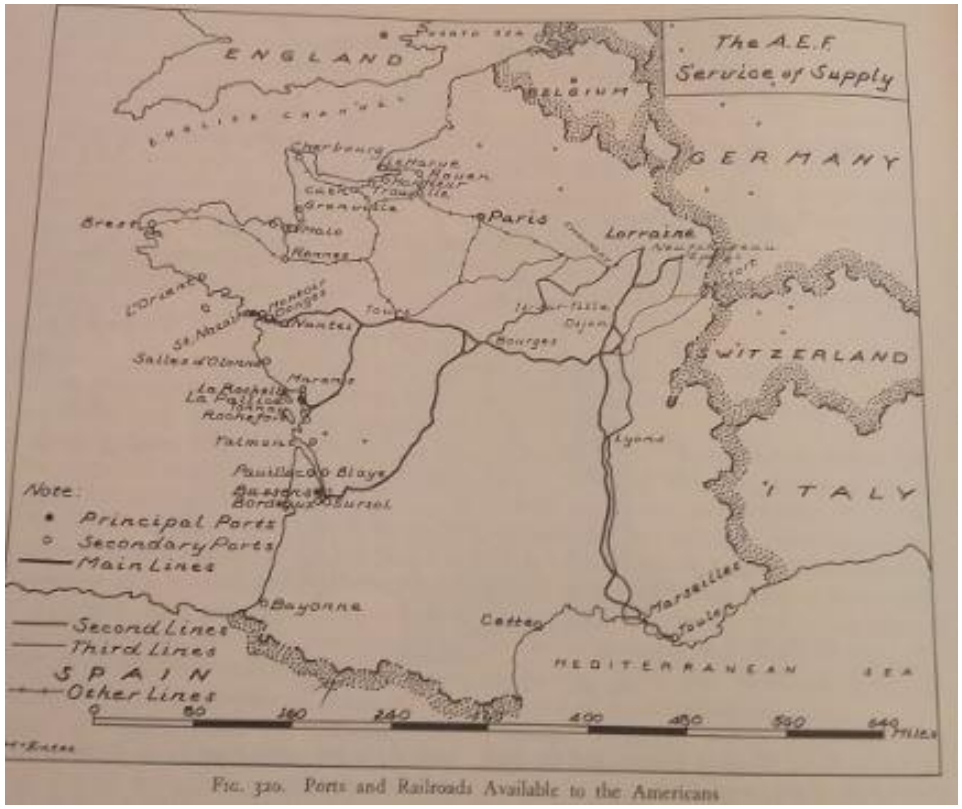
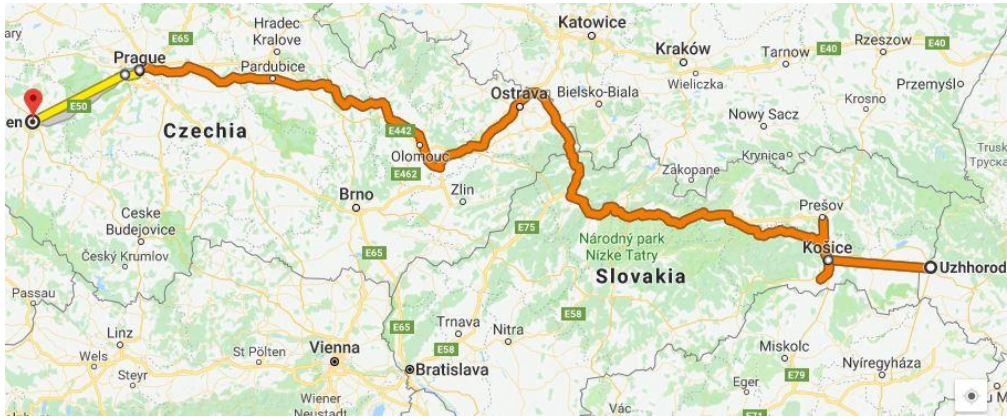


Fig. 320. Ports and Railroads Available to the Americans

- For comparison, during the First World War (the most recent conflict in which western Europe made mass use of rail to deploy troops directly into combat positions):
- The Western Front FLOT was on average 125km ahead of the standard-gauge railhead

Logistical Depth Questions

- During the Cold War, Soviet broad-gauge rail lines remained 700-1,200km behind the inter-German and 850km behind the Bavarian-Czechoslovak borders
- Combat operations against NATO would therefore rely largely on in-place Soviet forces without massive construction of new rail networks

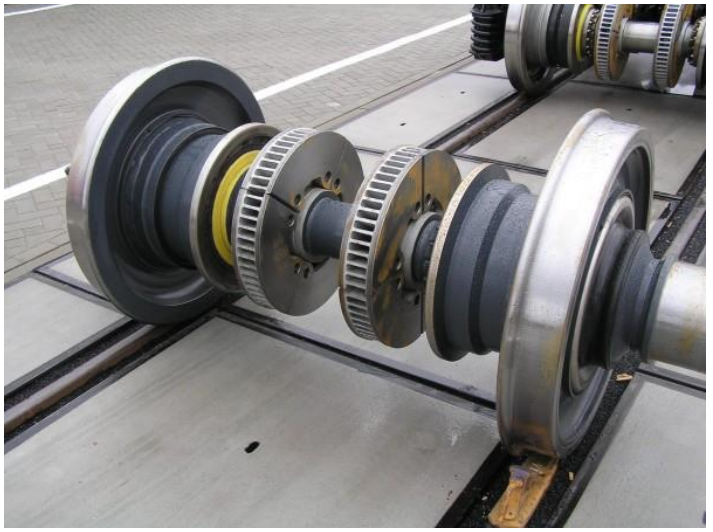


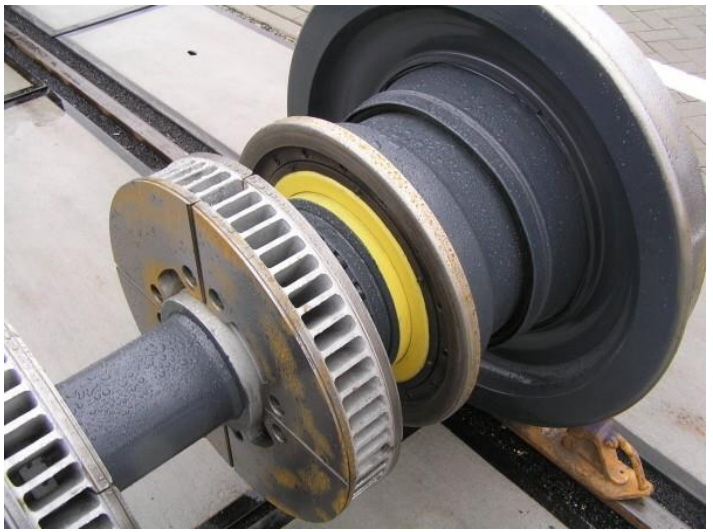
Development of Interchange Technology

- Communist-bloc COMECON trade interaction in a rail-dominant logistics network created impetus for creating automated rail gauge interchange devices
- This complemented other Soviet efforts to electrify and mechanize their rail lines through the 1960s and 1970s

Development of Interchange Technology

- SUW 2000: 30 minute adjustment time
- Manual adjustment: 65 minute adjustment time (per rolling stock car)
- However, these technologies are limited by how many interchange nodes to which they can be equipped





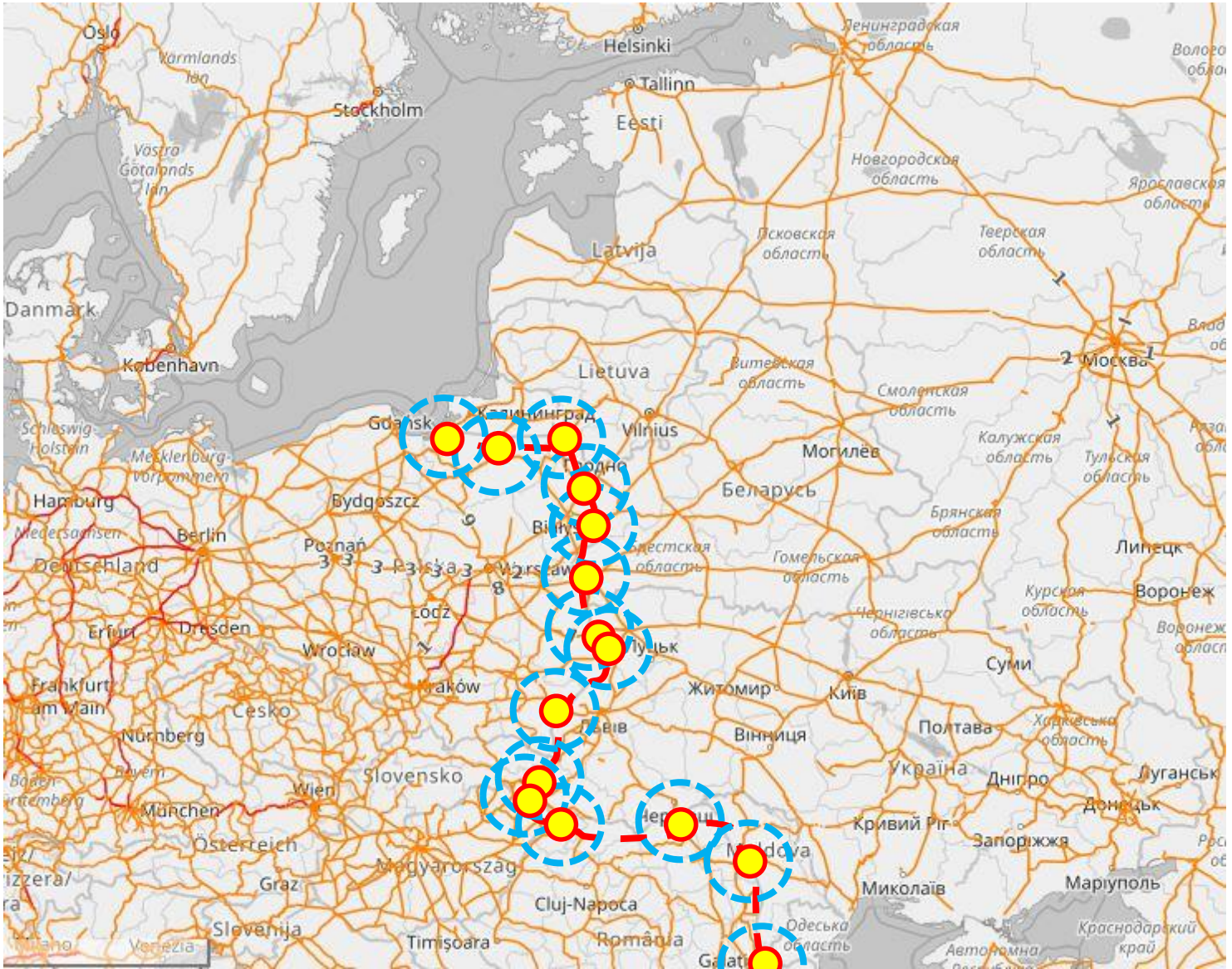
Historical Operations Analysis

Russian Rail Construction Rate (km/day/BGE)	
1840s	0.201
1851-1876	0.331
1878	**3.050**
1890-1905	0.125
1907-1914	0.127
1914-1915	**1.614**
1941-1945	**3.661**
1945-1966	0.156
Post-Cold War	0.420

Rail Gauge Conversion Rate (hours)	
Manual Adjustment	663 (82.9)
Manual Reloading	11
Mechanized Reloading	7
SUW 2000	0.5

Modern Rail Network

Modern Rail Network

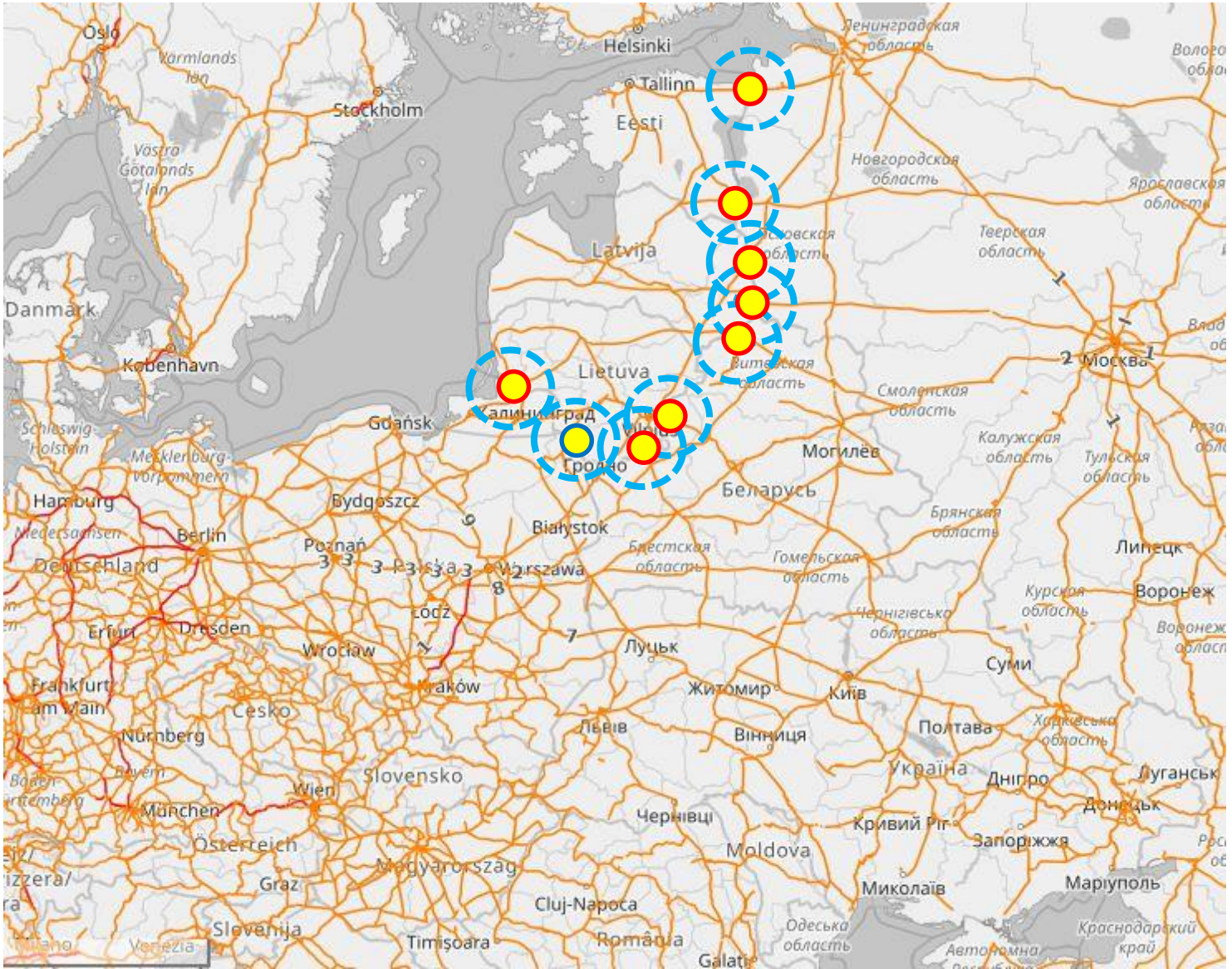


Rail Depth Operational Analysis

Western Distance from Standard-Gauge Railhead to (Anticipated) Front	
World War I	125km
Cold War (FRG)	0-125km
Post-2003 NATO	Up to 800km

Russian Distance from Broad-Gauge Railhead to (Anticipated) Front	
World War I	40-300km
Cold War	1,000-1,200km (700km)
Post-2003 NATO	0-100km

21st Century NATO Supply



Multiple COAs?

- Just as the post-1945 Soviet Union found its traditional means of supply overly constraining upon its perceived logistical needs, NATO today needs multiple potential solutions to assuredly reinforce the Baltic States:
  1. Constructing standard-gauge rail into the Baltic States
  2. Improving point-defense capabilities of specialized gauge exchange nodes
  3. In-place defensive units distributed to minimize possibilities of initial suppression strikes
  4. Training railway units for the rapid restoration of the rail line over the Suwalki Gap
  5. Additional forward deployment of defensive units
  6. Practice conducting maneuver operations with very long (700km) LOCs
- These COAs combined offer the most options

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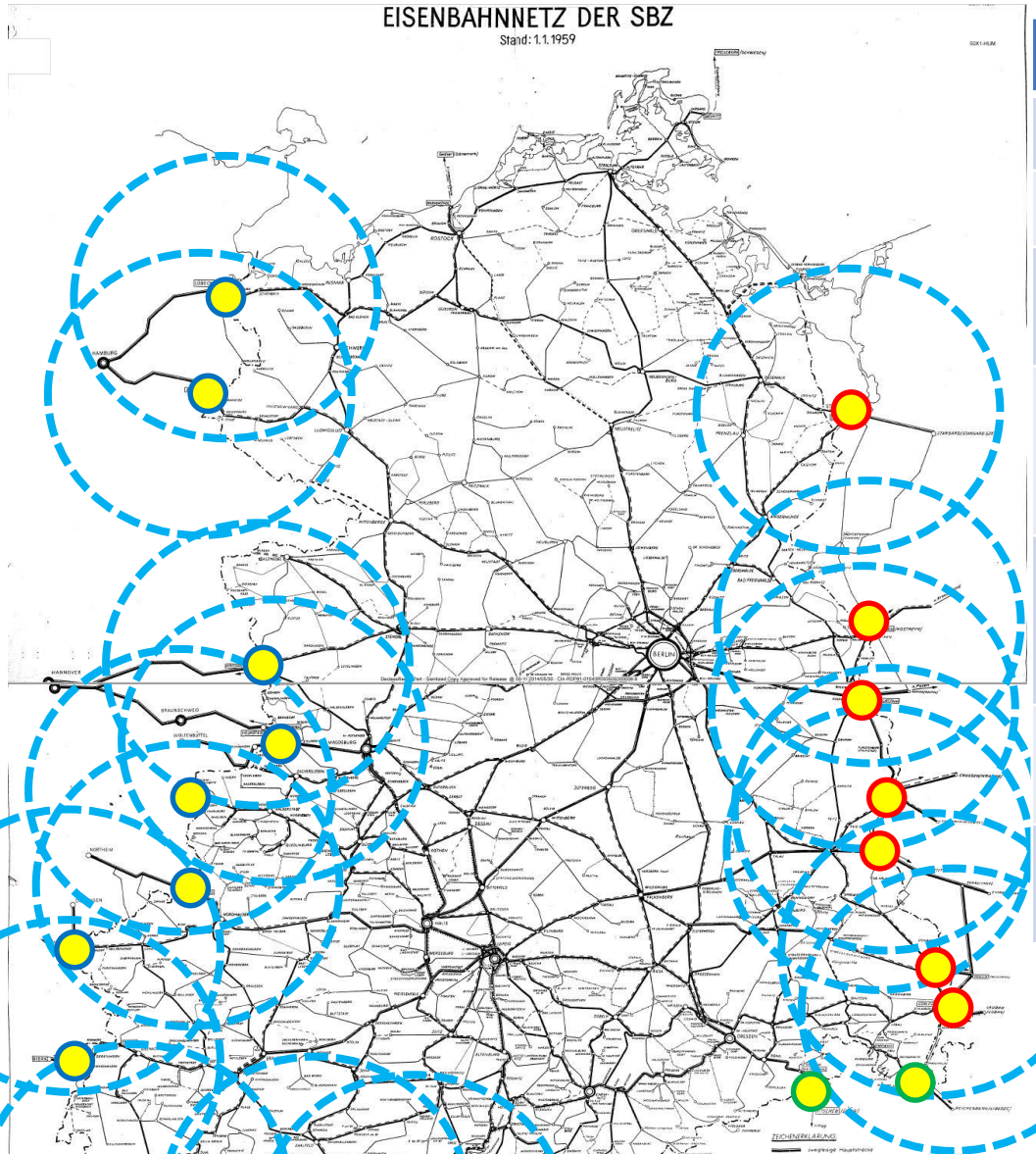
A Soviet Solution



	East Germany	Baltic States
Population	16,616,000	6,054,250
Area (sq km)	108,333	175,228
B/R Rail Crossings	11/7	1/8(5)
Blue Forces	494,300 (401,800)	30,260 (3,238) [~106,000]
Red Forces	173,100 (380,000) [~400,000]	~30,000 (10,000-)
B/R Ratio	1.62 (0.94)	1.12 (0.83)
CZS/TsVO	1.09 (0.73)	0.91 [2.97]

ZVO Russian Railway Troops OOB