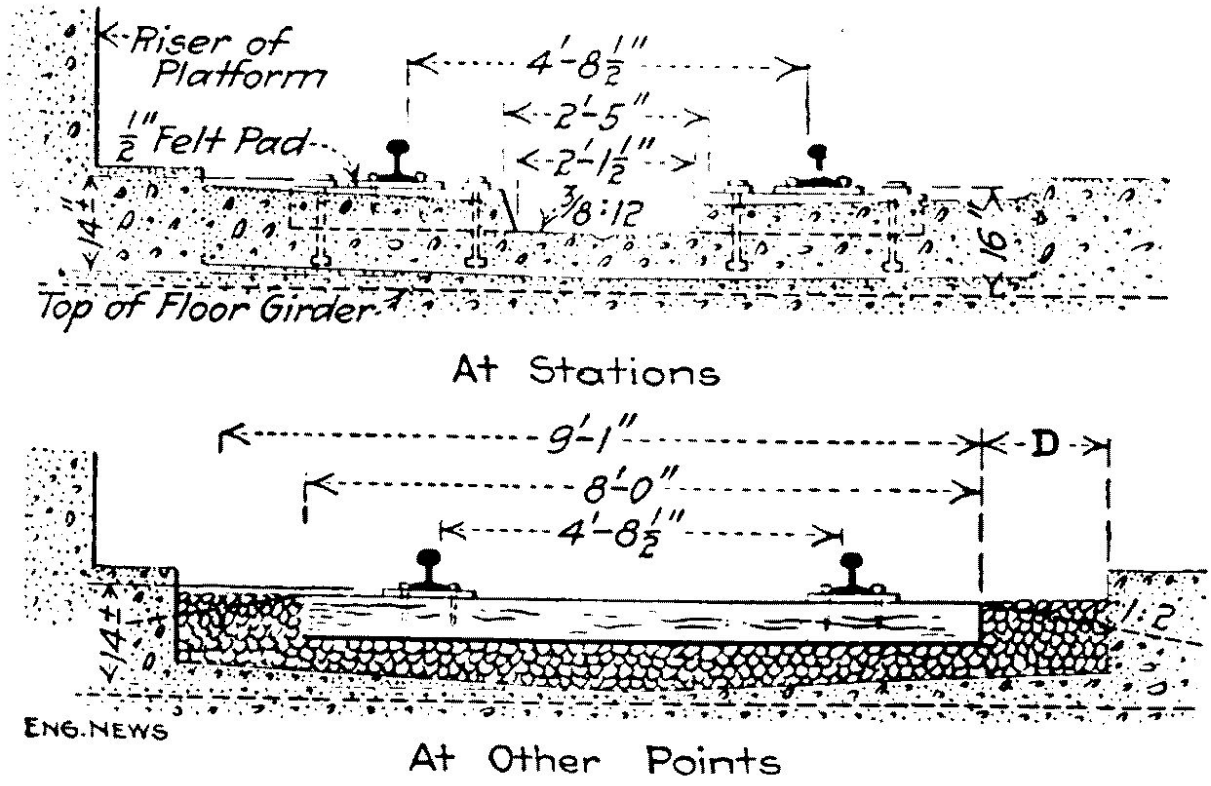
List of Variables to Measure

- Longitudinal profile and horizontal alignment of both running rails
- Track gauge
- Tunnel and platform clearances
- Corrugation of running rail surface
- Third rail height and gauge
- Vertical gap between the top of the third rail and the protective board
- Internal rail flaws
- Track grade
- GPS/Tracking Location

Omar:

- https://en.wikipedia.org/wiki/R160_(New_York_City_Subway_car)
- Track gauge: 1,435 mm (4 ft 8.5 in)
    - Standard Gauge
- 625V DC Third Rail (600-650)
- https://en.wikipedia.org/wiki/New_York_City_Subway
- https://www.nycsubway.org/wiki/Chapter_04._Design_of_Structure_and_Track



- http://web.mta.info/nyct/facts/ffsubway.htm

- **The holy grail: http://web.mta.info/nyct/procure/addenda/200808add18.pdf**

- http://web.mta.info/mnr/html/geometrylesson.html
- https://www.railwaygazette.com/news/technology/single-view/view/mta-metro-north-orders-ensco-track-geometry-vehicle.html
- https://absopulse.com/750vdc-high-input-voltage-railway-dc-dc-converters-transit-mining-vehicles/
    - https://absopulse.com/wp-content/uploads/2018/08/HVI-500R-FX-high-input-voltage-railway-converters.pdf

Track geometry car[edit]

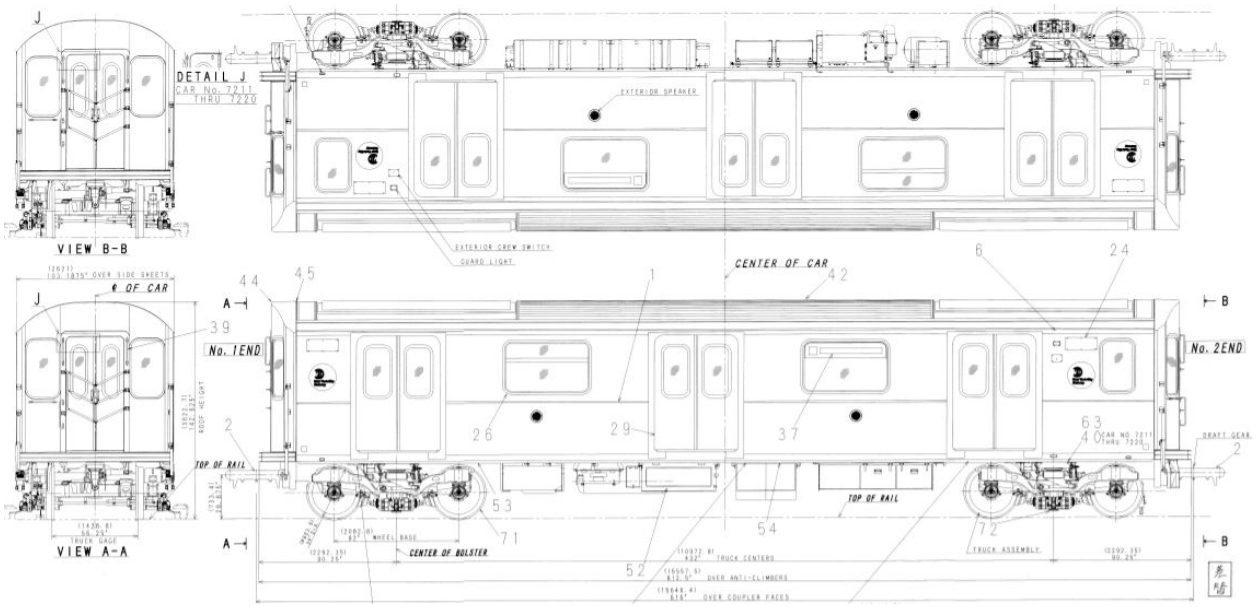
The track geometry car at Jay Street – MetroTech.

There are four track geometry cars on the New York City Subway that measure the system's track geometry to ensure that safe train operation is maintained. The cars are numbered TGC1–TGC4. TGC1 was ordered under contract R59 in 1984 for $1.4 million.[36] The other three were ordered under contract R63 and cost $2.5 million each.[37][38] The cars use sensors, measuring systems, and data management systems to get a profile of the tracks. The train crew consists of two track equipment maintainers, one maintenance supervisor, and two to three engineers. The trains typically operate during off-peak weekday daytime hours so as to not interfere more frequent rush hour service. A single car weighs 45 tons.[38] The cars measure:

- Alignment – “Alignment is the projection of the track geometry of each rail or the track center line onto the horizontal plane,” (FRA Definition).[39] Also known as the “straightness” of the tracks.
- Crosslevel – The variation in cant of the track over the length of a predetermined “chord” length (generally 62 feet or 18.90 meters). On straight or tangent track, ideally there should be no variation, while on curves, a cant is generally desired.
- Curvature — The amount by which the rail deviates from being straight or tangent. The geometry car checks the actual curvature (in Degree of curvature) of a curve versus its design curvature.
- Rail gauge — The distance between the rails. Over time, rail may become too wide or too narrow. In North America and most of the world, standard gauge is 4 ft 8½ in (1,435 mm).
- Rail profile — Looks for rail wear and deviations from standard profile.
- Warp – The maximum change in crosslevel over a predetermined chord length (generally sixty-two feet).[40]
- Corrugation of running rail surface
- Tunnel and station platform clearances
- Third rail height and gauge
- Vertical gap between third rail and protective board [41]

The track geometry car typically checks each stretch of track about 6 times a year; the car is manually operated, and there are no plans to automate inspection of the track geometry, which is done manually with the help of high-tech equipment aboard the car.[42]

- https://en.wikipedia.org/wiki/New_York_City_Subway_rolling_stock#Track_geometry_car
- http://www.mta.info/news/2012/10/30/new-york-city-transits-wonder-train-car

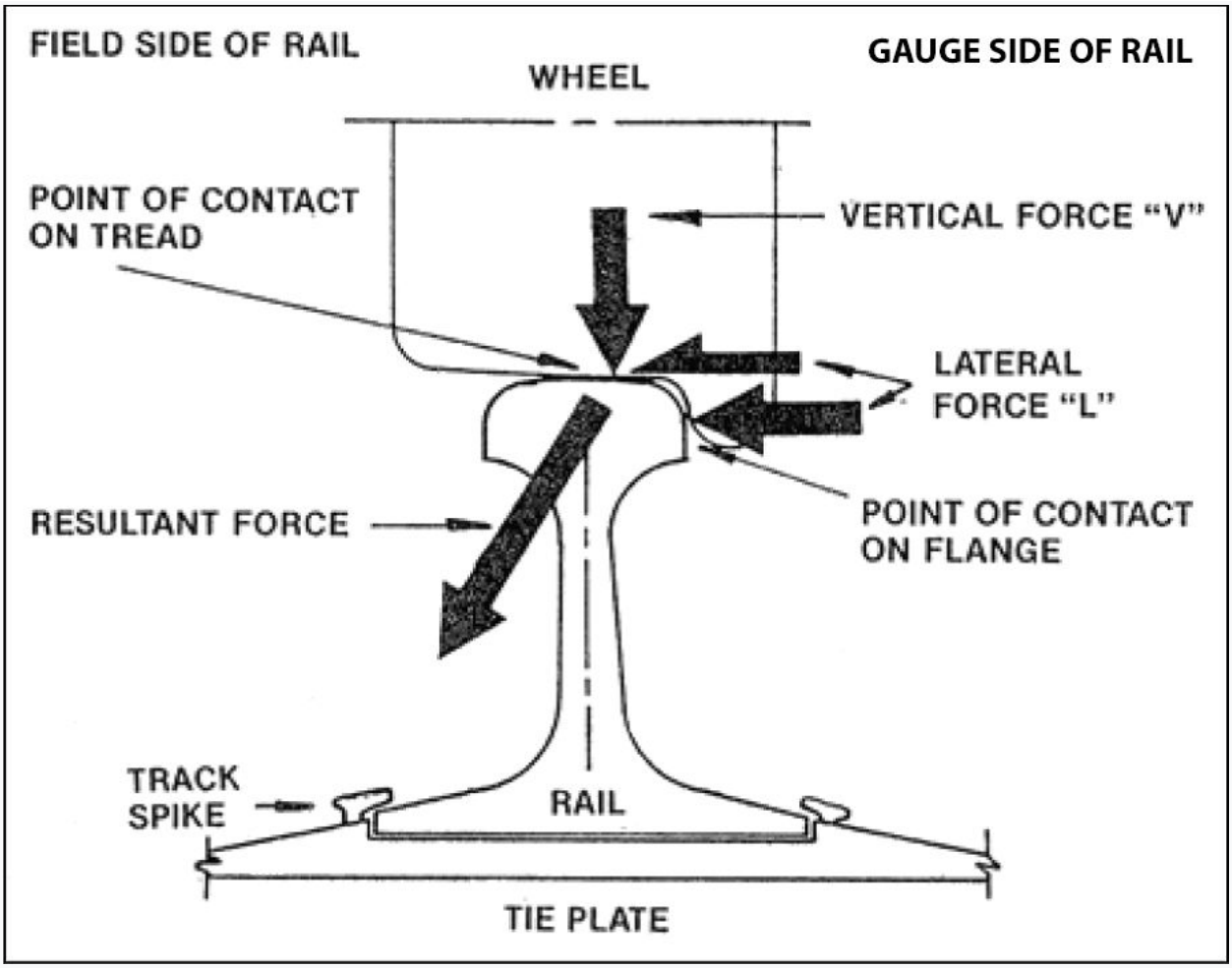


https://www.kawasakirailcar.com/R142A
http://www.thejoekorner.com/cars/NYC-Subway-Car-Datasheet.pdf

- clearance limits as depicted in NYCT MW-1, “Track Standards and Reference Manual” and the NYCT MOU, “Memorandum of Understanding for Car and Line Equipment Clearance.” The Pump and Generator cars shall remain within the clearance outline shown in the clearance envelope for all conditions and/or combinations of dynamic motion, wear of components, all loading, vertical and horizontal curves, suspension system deflection, and any single suspension system failure. No part of the trucks, except wheels and trip cocks, shall be less than 2.5 inches R32443 2-4 Pump and Generator Car Specification (64 mm) above the plane of the top of the rails.
    - http://web.mta.info/nyct/procure/addenda/200808add19.pdf
- NYCT Memorandum of Understanding - Car and Line Equipment Clearances : A Memorandum of Understanding - Car and Line Equipment Clearance was developed by NYCT and issued in March of 2001 . This memorandum establishes the background, definitions, and interpretation of the wayside and car clearances required for the safe operation of trains in the NYCT rapid transit system. The clearance requirements set forth in the memorandum are a guide used in the construction and maintenance of tracks, structures, line equipment, signals, stations, and power distribution . It is also used in the design, construction and maintenance of all passenger cars and work equipment . Clearance lines for equipment were established by taking the largest static car outline of a car operating in the system and adding to it, both vertical and lateral margins of safety to compensate for wear of items on the cars and/or the tracks (such as rails, wheels, etc .) . On curved tracks, the car clearance envelope was further adjusted to allow for car end excess, center excess, and super-elevation. After consideration of all these factors, the result is a car outline that establishes the Limiting Line of Car Clearance. In order to compensate for the normal dynamic movement associated with

the cars as they travel along the tracks, a two inch lateral and a one inch vertical "safety zone" was added to the Limiting Line of Car Clearance measurements. This new outline is known as the Limiting Line of Line Equipment. Under normal operating conditions, no part of the car body or equipment should encroach beyond the Limiting Line of Line Equipment.

    - https://www.dot.ny.gov/divisions/operating/osss/rail-repository/6709%20Collision%20Case.pdf
- **https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA_Report_No._0049.pdf**
- 29 m (95 ft) minimum curve radius
- https://www.nycsubway.org/wiki/The_New_York_Subway:_Chapter_08,_Rolling_Stock,_Cars,_Trucks,_Etc.
- https://www.businessinsider.com/subway-car-factory-2014-9#once-a-car-is-complete-it-is-brought-to-the-end-of-the-track-where-two-traverser-tables-pick-up-each-truck-the-tables-are-remote-controlled-and-are-used-to-move-the-cars-to-flatbed-trucks-or-to-the-tracks-outside-from-there-its-off-to-the-subway-system-and-a-long-life-transporting-you-all-over-the-city-1117
- Bms bcp



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Marcin Wisniowski:

- New Autonomous Track Geometry Inspection System (ATGIS) purchase by MTA for continuous inspection data.
    - http://www.mta.info/news-metro-north-metro-north-railroad-safety/2014/05/16/metro-north-purchase-advanced-track
- If we are to get in contact with MTA, ask about their Asset Management guidelines and which actual data points they measure.

Noah:

- https://www.nap.edu/read/22394/chapter/13
  - "Each transit agency has its own maintenance standards and many use either APTA or the FRA for their safety standards."

Item	Description of Defect	Class of Track	Max passenger speed in mph APTA and FRA	APTA		FRA		Agency Maintenance Criteria																	
								A		B		C		D		E		F		G		I		J	
				Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in	Min in	Max in
1	Variation from standard gage	1	15	-½	1½	-½	1½	-¼	¾	-¼	¾	-½	1	-⅝	1	-½	1¼	-½	1	-¾	1¼	-½	1½	-½	1
		2	30		1¼		1¼						⅞					-¾	¾				1¼	-¾	⅞
		3	60								½		¾		⅞	-7/16	1			-¾	1				
		4	80		1		1						¼			-⅝	¾	-¼	½				1	-¼	½
		5	90																						
2	Variation in alignment - 62' chord - Tangent	1	15		5		5		1	No Criteria			1		2		3		5	No Criteria			5		2¼
		2	30		3		3		¾				½		1½		2		3				3		1½
		3	60		1¼		1¼				½		¾		1¼		1½						1¼		
		4	80		1½		1½		½				0		1		1¼		1½				1½		1
		5	90		¾		¾								¾								¾		
3	Variation in alignment - 31', ( ) = 62' chord - Curve	1	15		3	N/A			⅝		1¼		1		(2)		2¼		(4)	1½	1½	N/A			1¼
		2	30			N/A							½		(1½)		1½		(2½)			N/A			1¼
		3	60		1¼		1¼				½		¾		(1¼)		1			¾	¾		1¼		
		4	80		1		1		¼				0		(⅝)		¾		(1¼)				1		⅝
		5	90		½		½				¼				(½)								½		
4	High Water ( ) = Height above base of Rail	1	15		Head	No Criteria		No Criteria			Head		6½	No Criteria			Head	No Criteria			Head	No Criteria		No Criteria	
		2	30		Web						Web		5				Web				Web				
		3	60										1¼												
		4	80		Base						Base		0				Base				Base				
		5	90										0												
5	Runoff in 31'	1	15		3½		3½		1½		3½	No Criteria			1½		1½		3		3		3½"		2½
		2	30		3		3		1		2				1				2¼		2		3		1½
		3	60		2		2								1		1½						2		
		4	80		1½		1½		½		1				¾				1½				1½		1¼
		5	90		1		1								½								1		
6	Surface Deviation 62' Chord	1	15		3		3		1½	No Criteria		No Criteria			2		3		2¾		2¾		3		2½
		2	30		2¾		2¾		1						1½		2¼		2¼				2¾		2
		3	60		2¼		2¼								1		2¼				2¼		2¼		
		4	80		2		2		¾						¾				1¾				2		1¾
		5	90		1¼		1¼								⅝		2						1¼		
7	Surface Deviation 31' Chord	1	15		1	No Criteria		No Criteria			¾		2	No Criteria			1	No Criteria			1¾	No Criteria		No Criteria	
		2	30		¾						9/16		1¼				¾								
		3	60		½								⅝				½				1¼				
		4	80		⅝						½		½				¾								
		5	90		¼																				

- https://www.fra.dot.gov/Elib/Details/L19466
  - FRA Track and Rail and Infrastructure Integrity Compliance Manual
- https://en.wikipedia.org/wiki/Rail_inspection
  - The defects mentioned here are worth reviewing, though the sensors required may make it infeasible to include in our scope.
  - The MW1000 manual found in this drive also mentions similar review of these defects such as transverse fissures.

Anthony:

- http://www.mta.info/news/2012/10/30/new-york-city-transits-wonder-train-car
  - Partial List of Specs
- https://gizmodo.com/this-superheroic-train-keeps-new-york-citys-subway-safe-1571987376
  - "The tracks also spread further apart as the gauge rods that hold them together slowly wear out. By the time the gauge is an inch-and-a-half wider than the standard, it's considered a priority one defect, important enough to dispatch a response team immediately."

- http://www.mta.info/press-release/nyc-transit/mta-nyc-transit-puts-new-track-safety-initiatives-place
    - New Track Safety Initiatives