ATTACHMENT 10 A

HSR CRITERIA

SIX CHANGES IN ONE HALF MILE:
(1) SUPERELEVATION: 0" TO 6" VARIES
(2) BVC: Begin vertical curve
(3) EVC: End vertical curve
(4) ST: SPIRAL TO TANGENT
(5) CS: Curve to Spiral Curve radius 28,000'

3.0 ASSESSMENT/ANALYSIS

3.1 ALIGNMENT CRITERIA

The alignment of the railroad shall be as smooth as practical with minimal changes in both the horizontal and vertical direction. Appearance, ease of maintenance, and ride quality are all enhanced by a smooth alignment with infrequent and gentle changes in direction. Over four changes in direction per mile shall constitute an Exceptional condition. (6) MAXIMUM VERTICAL GRADE

All alignment element segments (vertical curves, lengths of grade between vertical curves, horizontal curves, spirals) shall have a minimum length sufficient to attenuate changes in the motion of the rolling stock. This length is defined by the time elapsed over the segment, and therefore varies directly with design speed. Not all systems have the same time requirements. This attenuation time varies from 1.0 to 2.4 seconds, and on the SNCF, up to 3.1 seconds at higher speeds. Segment length requirements will govern only where design considerations for the various elements do not require longer segment lengths.

Vertical and horizontal alignment sections may overlap. Overlap of horizontal spirals and vertical curves shall be an Exceptional condition. Based on European high-speed rail standards, the Minimum distance between the end of a spiral and the beginning of a vertical curve or the end of a vertical curve and the beginning of a spiral is 50 meters (160 feet) with an Exceptional limit of 30 meters (100 feet).

3.1.1 Minimum Segment Length due to Attenuation Time

Attenuation time, based on the most conservative requirements, shall be:

- For V < 300 km/h (Under 186 mph)
  - Desirable attenuation time: not less than 2.4 seconds
  - Minimum attenuation time: not less than 1.8 seconds
  - Exceptional attenuation time: not less than 1.5 seconds
  - An attenuation time of 1.0 seconds on the diverging route in curves adjacent to or between turnouts
- For 300 km/h ≤ V (Over 186 mph)
  - Desirable attenuation time: not less than 3.1 seconds
  - Minimum attenuation time: not less than 2.4 seconds
  - Exceptional attenuation time: not less than 1.8 seconds

Minimum segment length is calculated by the formula: $L_{feet} = V_{mph} \times 44/30 \times t_{sec}$ and $L_m = V_{km/h} / 3.6 \times t_{sec}$. Sample minimum segment lengths are presented in Tables 3.1.1 and 3.1.2.

Table 3.1.1: Minimum Segment Lengths at Various Speeds of 300 km/h (186 mph) and higher

Design Speed		Minimum Segment Lengths for times of							
		3.1 seconds		2.4 seconds		1.8 seconds		1.5 seconds	
miles per hour	km/h	feet	meters	feet	meters	feet	meters	feet	meters
250	400	1137	346	880	268	660	201	550	168
220	355	1000	305	774	236	581	177	484	148
200	320	909	277	704	215	528	161	440	134
186	300	846	258	655	200	491	150	409	125
175	280	796	243	616	188	462	141	385	117
150	240	682	208	528	161	396	121	330	101

ATTACHMENT 10B

HSR CRITERIA

4.0 SUMMARY AND RECOMENDATIONS

The primary objective in setting alignment is to develop the smoothest practical alignment within the limitations imposed by location of stations, urban areas, mountain crossings and major stream crossings as well as environmental and political constraints. It is also important to consider the optimization of earthworks movement, tunnel length, drainage and structures. The radii of horizontal curves, in particular, should be larger than "Desirable" values wherever it is practical to do so. Going below "Desirable" values for the various portions of the alignment should not be treated lightly. Very seldom will an alignment as finally designed and built be better than that set out initially. Quite frequently points will be "locked in" very early in the study process. This is particularly true for the horizontal component of alignment.

Use of Minimum and Exceptional values should be held back to the greatest extent practical for use in the adjustments due to unanticipated constraints that will always occur.

It is very easy to get into a "can't see the forest for the trees" situation. At frequent intervals the designer should step back and look at things globally. This, in particular, means plotting condensed profiles, and looking at the layout over long segments. When transitioning from low speed areas to high-speed areas, consider the operating characteristics of both presently available trains and characteristics of trains with anticipated improvements in power, acceleration and braking. Sudden jumps in speed do not happen with trains.

There should be a relationship between horizontal and vertical alignment standards. For example, there is no point in using vertical curves designed for 250 mph which are adjacent to curves or other constraining elements that permanently restrict speeds to a much lower value. However, the speed used in developing vertical curves should never be lower than that possible under "Exceptional" conditions on adjacent horizontal curves.

It is not possible for this document to anticipate all eventualities, nor to be a textbook in alignment design practices, nor is it intended to be used as a substitute for good engineering judgment.

Table 3.3.2-2: Minimum Vertical Curves – Rates of Change and Equivalent Radii (0.90 ft/s^2 = 2.80% g)

Speed mph	Speed km/h	% change per 100 feet	feet per % of change	Radius feet	Radius meters
300	480	0.045%	2150	215,000	66,000
250	400	0.065%	1500	150,000	46,000
220	355	0.085%	1160	116,000	36,000
200	320	0.100%	960	96,000	30,000
175	280	0.130%	740	74,000	22,500
150	240	0.180%	540	54,000	16,500
125	200	0.260%	375	37,500	11,500

Table 3.3.2-3: Exceptional Vertical Curves – Rates of Change and Equivalent Radii (1.4 ft/s^2 = 4.35% g)

Speed mph	Speed km/h	% change per 100 feet	feet per % of change	Radius feet	Radius meters
300	480	0.070%	1400	140,000	43,000
250	400	0.100%	970	97,000	30,000
220	355	0.130%	750	75,000	23,000
200	320	0.150%	620	62,000	19,000
175	280	0.200%	480	48,000	15,000
150	240	0.250%	350	35,000	11,000
125	200	0.400%	250	25,000	7,500

The lengths developed in the preceding tables and formulae are the shortest allowed lengths for each scenario. Vertical curve lengths shall always be rounded up, usually to an even 100 feet multiple. Rate of change and other parameters shall then be derived from that length.

Where the difference between gradients is small, the minimum segment length requirements described in Section 3.1.1 shall determine the minimum length of vertical curve. Rate of change, radius and other parameters of the vertical curve shall then be derived from the length.

3.3.3 Vertical Curve / Horizontal Curve Combinations

Vertical and horizontal curves can overlap. Crest vertical curves result in a downward acceleration of the vehicle, thereby reducing the gravitational effect. This reduction is small but not insignificant for the vertical curve rates of change permitted in this document. A reduction of 0.25 inches for limiting and 0.50 inches for exceptional unbalanced is sufficient to allow for this effect.

3.3.4 Other Vertical Curve Restrictions

It is neither practical nor possible to provide a set of rules that cover all situations. It is anticipated that the information in this document will be applied with good engineering judgment.

Vertical Curves in Spirals: Due to potential maintenance difficulties, it is desirable to avoid use of vertical curves in spirals. The desirable distance between end of spiral and beginning of vertical curve or end of vertical curve and beginning of spiral is 160 feet (50 m) with a minimum limit of 100 feet (30m). Overlap between vertical curves and spirals may be permitted as an Exceptional condition, but only where it can be shown that practical alternatives have been exhausted.

NO OTHER PRACTICAL ALTERNATIVES SUBMITTED IN DEIR OR FEIR EXCEPT FOR UPRR ALIGNMENT.

ATTACHMENT 10 D
HSR CRITERIA

6.1.7 Horizontal Curves in Vertical Curves

Unbalanced Superelevation Limits: Horizontal and vertical curves can overlap. Crest vertical curves result in a downward acceleration of the vehicle, thereby reducing the gravitational effect. This reduction is small but not insignificant for the vertical curve rates of change permitted in this document. A reduction of 0.25 inches for limiting and 0.50 inches for exceptional unbalanced superelevation is sufficient to allow for this effect.

Vertical Curves in Spirals: Due to potential maintenance difficulties, it is desirable to avoid use of vertical curves in spirals. The desirable distance between end of spiral and beginning of vertical curve or end of vertical curve and beginning of spiral is 160 feet (50 m) with a minimum limit of 100 feet (30m). Overlap between vertical curves and spirals may be permitted as an Exceptional condition, but only where it can be shown that practical alternatives have been exhausted.