

TO: M.N.S., R.C.L

(NO OTHER COPIES)

11

FROM: DNR

SUBJECT: VEHICLE ROLLOVER - CJ-TYPE VEHICLES

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A fairly simple steady state handling calculation can be used to give a "ballpark" indication of how easily a vehicle will roll over.

If the vehicle is driven in a true circle on a flat dry skidpad at increasingly higher speeds, it will be subjected to increasingly higher lateral acceleration. As this lateral "g level" is increased, at some point the vehicle will either skid out or roll over.

The g level at which a given vehicle will roll over is principally a function of its C.G. height relative to its track width. On page 3 are calculated values of roll over g level for our CJ7 and other vehicles. They range from a low of 0.67 for the Diabaton F20V to a high of 1.26 for the Pace. While these figures are useful for comparative purposes, "real world" factors will cause the vehicles to roll at somewhat lower values.

Most normal vehicles will skid out at 0.65 to 0.75 g. Page 4 gives a summary of "Road and Track" test data on passenger and sport cars.

Considering "real world" factors, I think any vehicle with an uncalculated roll over g level of 0.80 or less will probably roll over quite easily on a skid pad.

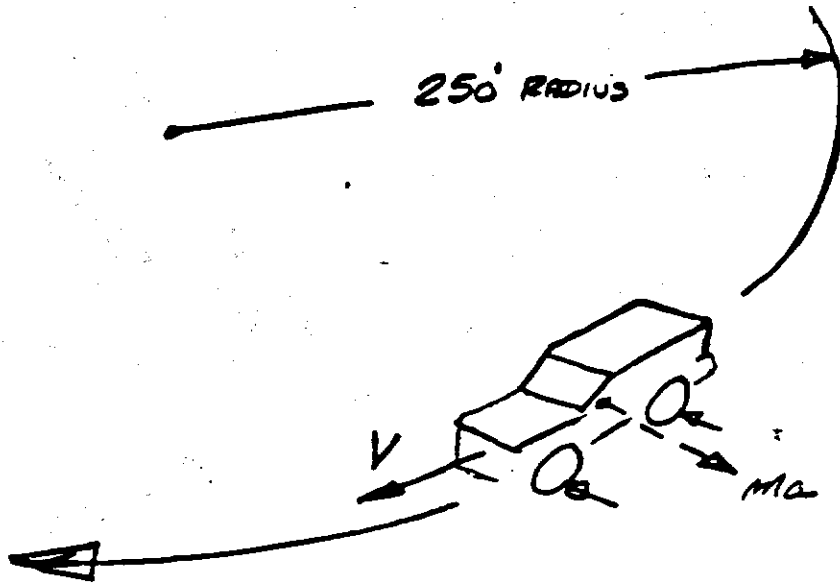
Values of 0.80 to 0.95 are marginal. Vehicles above 0.95 probably can not be made to roll over unless they are "tripped" by sliding into a curb or other obstruction.

Page 2 shows relationship between g level and skid pad speed.

DNR.
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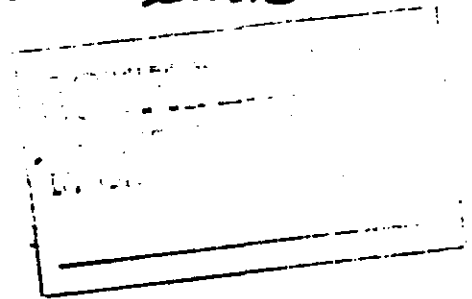
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Relationship of speed to g level in typical skid pad test.



Speed vs "g" level for 250' radius turn

<u>Speed</u>	<u>"g" level</u>
30 mph	0.24
40 mph	0.43
45 mph	0.54
50 mph	0.67
55 mph	0.81
60 mph	0.96

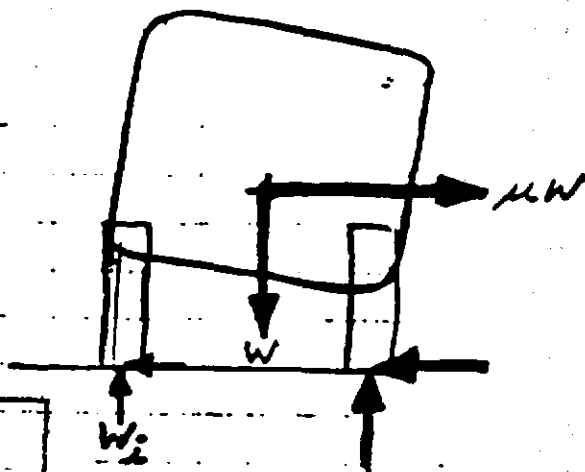
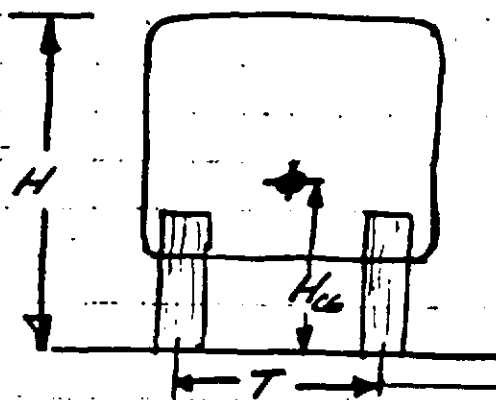


- ← CJ-Type Vehicle rolls over
- ← Good passenger car skids out
- ← Good sports car skids out

Lateral acceleration is proportional to $\frac{V^2}{R}$

WEIGHT TRANSFER IN CORNERING - CJ-II VS COMPETITORS

4 PASSENGER LOAD



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VEHICLE	TRACK (T) AVE OF FRONT & RR.	OVERALL HEIGHT (H) (CURB)	HEIGHT OF CG. (H _{CG}) (4 PAS)	PERCENT WEIGHT TRANSFERRED OFF INSIDE WHEELS IN 0.6 G CORNER	LATGICAL G. TO CAUSE ROLLOVER
<u>CJ-II HATCH</u>	54.0	65.0	26.0	67%	.93
DAIHATSU FE0V	47.0	73.0	31.0	90%	.67
CJ7 HATCH	50.75	70.6	30.0	81%	.75
TOYOTA KJ00V	55.2	76.0	32.0	79%	.78
79 WAGONER	58.6	66.7	26.5	63%	.99
SJ-II	61.25	65.5	26.0	59%	1.06
79 BRONCO	64.35	74.8	31.5	67%	.93
79 CONCORD	57.63	53.0	21.0	53%	1.22
79 PACER	60.75	54.5	21.5	51%	1.26
PINZBAUER	56.7"	81.5"	33.0"	79%	0.78
EAGLE	58.6	56.0	23.8	58%	1.10



IntraCompany Correspondence

To:
D. E. Dawkins
R. C. Lunn

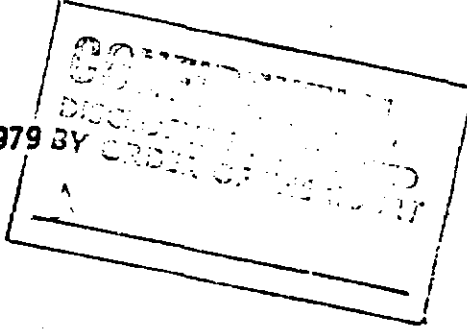
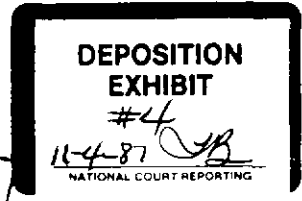
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From:
D. N. Renneker

Subject:
Answers to Questions
on CJ Rollover

Date:
July 26, 1979



Attachment #1

Graph of vehicle CG height and track vs. lateral g to cause rollover. Any combination of CG height and track which plot on the $u = 0.8$ line will theoretically roll over at 0.8 g's.

I believe a true safe design limit to be 0.9 g's. Any vehicle which falls below the 0.9 line on the graph will not roll over on a smooth surface. Any above probably will. The greater the perpendicular distance from the point to the 0.9 line, the greater the tendency to roll. From the graph, you would expect the CJ-7, Toyota FJ-40 and Pinzgauer to act about the same, but the Daihatsu to be significantly worse.

In reality, I expect the Pinzgauer to be worse than the CJ-7 because of its swing axle suspension.

Attachment #2

This graph illustrates the magnitude of change required to improve the CJ-7 to the level of the CJ-II ($u = 0.93$). Proposal A is CG lowering only. With no track increase, the CG would have to be lowered by 5.9" - an impossible task. Proposal B, track increase only, is equally impractical - requiring 10.9" of increase.

Proposals C and D involve 1.0" of CG lowering and 2.0" to 4.0" of track widening. While not a cure for rollover, I believe a change of this magnitude would make a significant improvement in the CJ.

In talking to the Steyr Puch engineers last week, I find they are working on a package of 1.0" CG lowering and 4.0" track increase to improve handling of the Pinzgauer. Their package, plotted on the graph as E, gets them from 0.78 to 0.86 - probably a worthwhile improvement.

I have started a study to determine feasibility of lowering the CJ-5 and 7 by 1.0". We are also looking at other handling improvement possibilities - tires, geometry, etc.

Answers to Questions
on CJ Rollover

Page 2

July 26, 1979

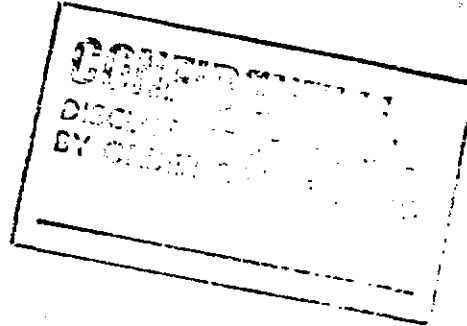
Attachment #3

Copy of my original letter on CJ rollover. Vehicle data on page 3 has been updated to include Pinzgauer and Eagle.

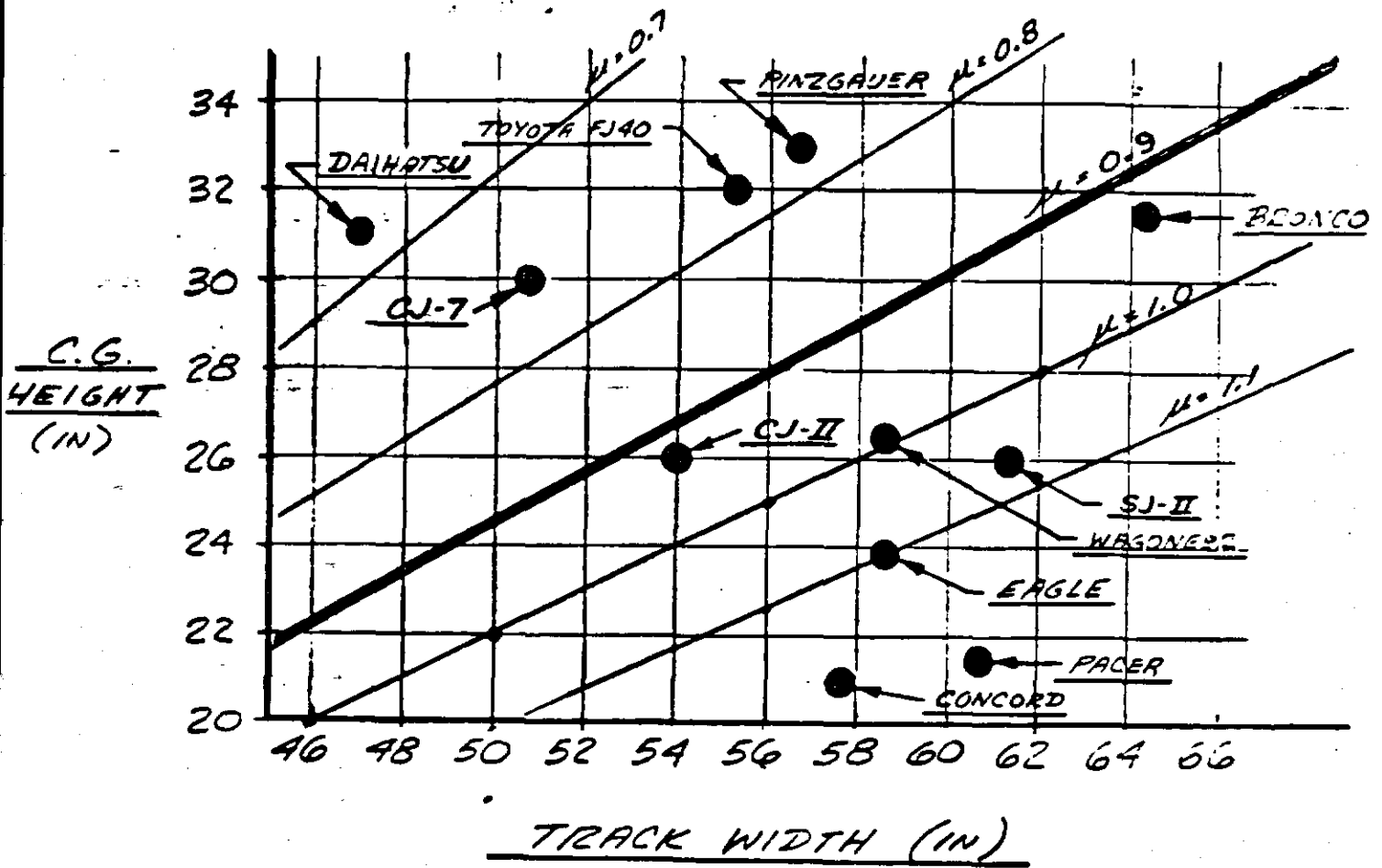
D. N. Renneker

D. N. Renneker

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Attachments

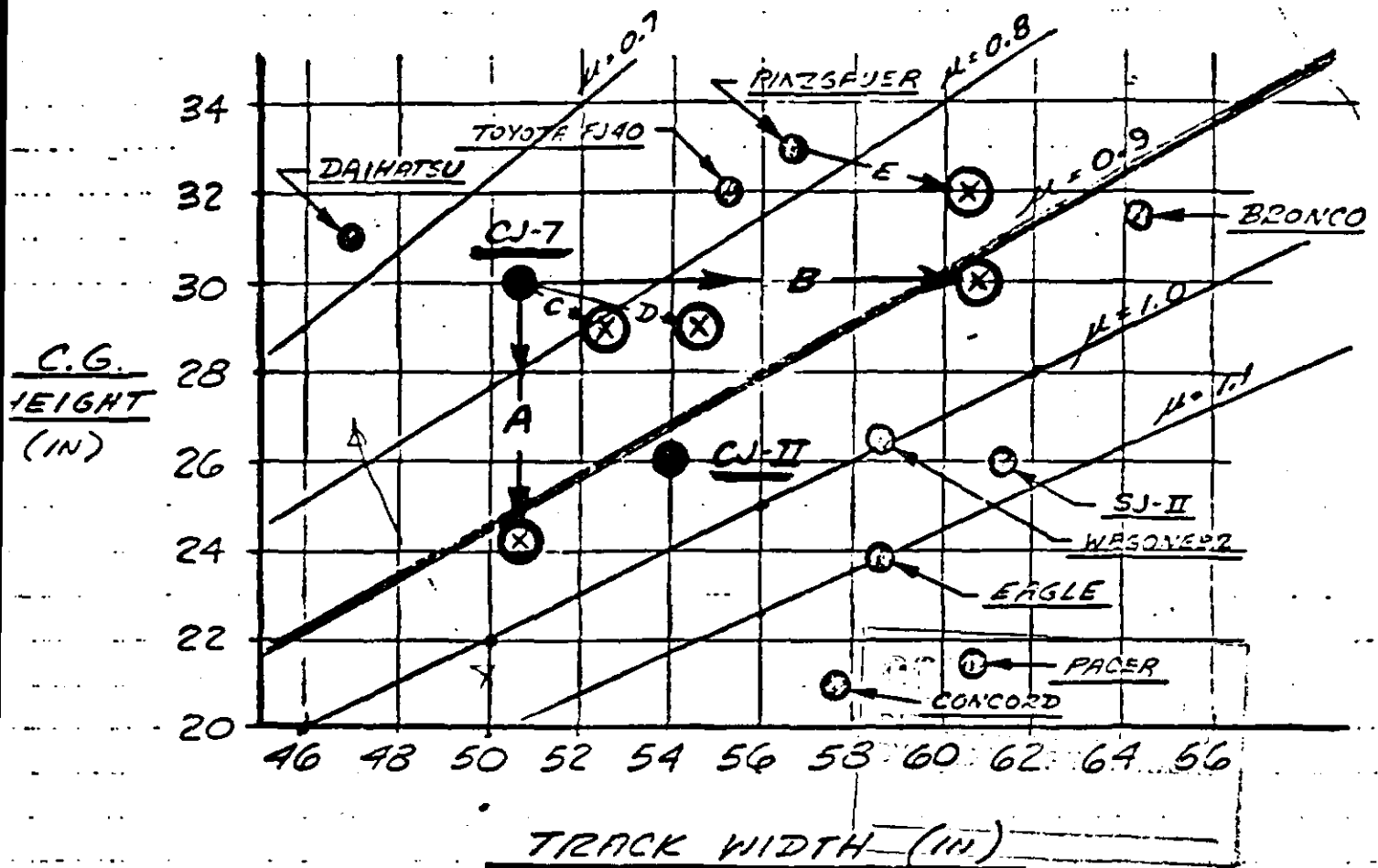


THEORETICAL LATERAL G (μ) TO CAUSE ROLLOVER



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THEORETICAL LATERAL G (μ) TO CAUSE ROLLOVER



CJ-7 PROPOSALS

	TRACK	CG. HT.	μ
• BASE CJ-7 HARDTOP	50.75	30.0	0.75
(A) • CG LOWERED <u>5.9"</u> , TRACK UNCHANGED	50.75	24.1	0.93
(B) • CG UNCHANGED, TRACK INCREASED <u>10.9"</u>	61.65	30.0	0.93
(C) • CG LOWERED <u>1.0"</u> , TRACK INCREASED <u>2.0"</u>	52.75	29.0	0.81
(D) • CG LOWERED <u>1.0"</u> , TRACK INCREASED <u>4.0"</u>	54.75	29.0	0.85

REF. CJ-II 54.0 26.0 0.93

REF. PINZGAUER IMPROVEMENT PROGRAM

• BASE	56.7	33.0	0.78
• CG LOWERED <u>1.0"</u> , TRACK INCREASED <u>4.0"</u>	60.7	32.0	0.86