vehicle fuel consumption in the age of autonomy

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we must explore new vehicle designs because
we could be doomed by proceeding with business as usual

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vehicle design is all about optimizing
a large set of intricately interconnected constraints

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removing the human from the driving control loop
is the largest change in design constraints
since the invention of the automobile

autonomous vehicle design from first principles.

$$fuel = \#mi \cdot \frac{kWh}{mi}$$

phoenix in 2013

Image courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center, ***ISS037-E-15970, https://eol.jsc.nasa.gov/***

N
1960, 19 $\frac{mi}{day}$

N
1960, 19 $\frac{mi}{day}$
2014, 44 $\frac{mi}{day}$ (~2.3x)

thought experiment

N
2014, 80 $\frac{min}{day}$, 32 mph

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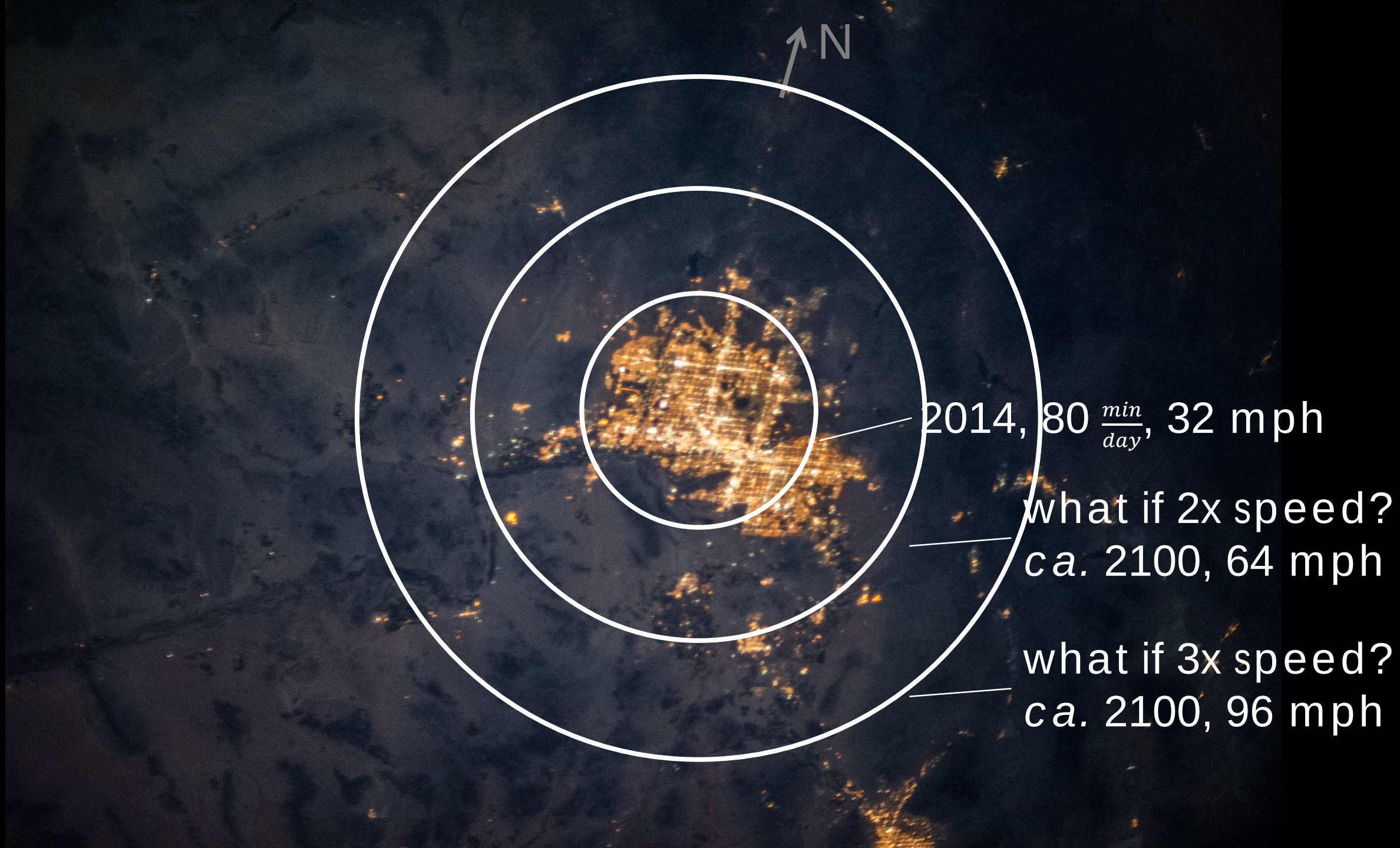
what if 2x speed?
ca. 2100, 64 mph


N
2014, 80 $\frac{min}{day}$, 32 mph
what if 2x speed?
ca. 2100, 64 mph
what if 3x speed?
ca. 2100, 96 mph

N
Gilbert
$200k+/acre
just outside of
Casa Grande
$1k+/acre

$$fuel = \#mi \cdot \frac{kWh}{mi}$$

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18 quads/year
300 million people

60 Q/B

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~2x

from increasing

VMT

120 Q/B

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18 quads/year
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$$\frac{kW}{v} = C_{RR} \cdot mg + \frac{1}{2}\rho \cdot C_D A \cdot v^2$$

$$+ \ motive\ energy\ loss$$

$$+ \ start|stop$$

$$+ \ grade\ losses$$

~2x

from increasing

VMT

120 Q/B

$$fuel = \#mi \cdot \frac{kWh}{mi}$$

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60 Q/B

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$$+ \; start|stop$$

$$+ \; grade\ losses$$

~2x
from increasing
VMT

120 Q/B

~2x
from tripling
velocity

240 Q/B

$$fuel = \#mi \cdot \frac{kWh}{mi}$$

18 quads/year
300 million people

60 Q/B

~2x

from increasing

VMT

120 Q/B

~2x

from tripling

velocity

240 Q/B

11 B

people in the year

ca. 2100

$$fuel = \#mi \cdot \frac{kWh}{mi}$$

18 quads/year
300 million people

60 Q/B

2640 Q

~2x
from increasing
VMT

120 Q/B

~2x
from tripling
velocity

240 Q/B

11 B
people in the year
ca. 2100

autonomous vehicle design from first principles.

so, what are those first principles of full autonomy?

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i could use your help!

there's an enormous combination of potential constraints.

our job is to find those most likely, and think about how to minimize fuel consumption in those contexts.

so, what are those first principles of full autonomy? FOR EXAMPLE

zero injury
ride like a lazy boy
get me there fastest
cheaper than just driving my dually

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(i didn't say)

fits a family of five
has good pedal feel and pick up
can crash into a wall at 35 mph
has to be statically balanced

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new design flexibility:

single passenger
low frontal area
ultra light weight
low power

Yamaha and SRI "Motobot"

can we make a two-wheel dynamically balanced autonomous pod?

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$C_D = 0.1$
$A = 1.5\ m^2$
$C_{rr} = 0.015$
$m = 500$ lbs

< 100 Wh/mi

@

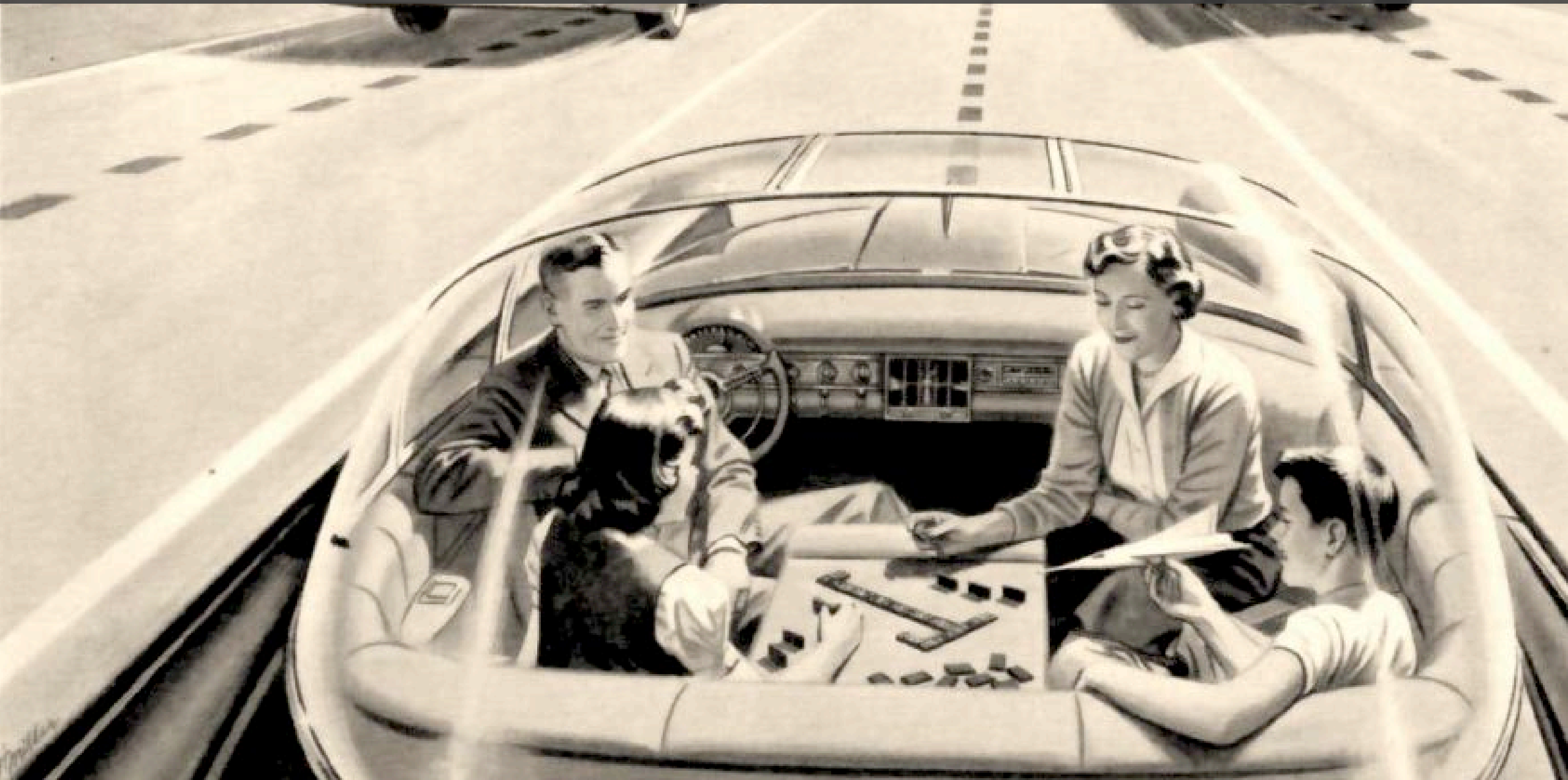
100 mph

(= 334 mpgge)

DARPA GXV-T program

ultra light and nimble vehicles
to dodge missles.

can we engineer the Toyota i-Road to dodge human-driven SUVs?

get in touch!

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