How different is ADAS?

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EDPS
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Outline

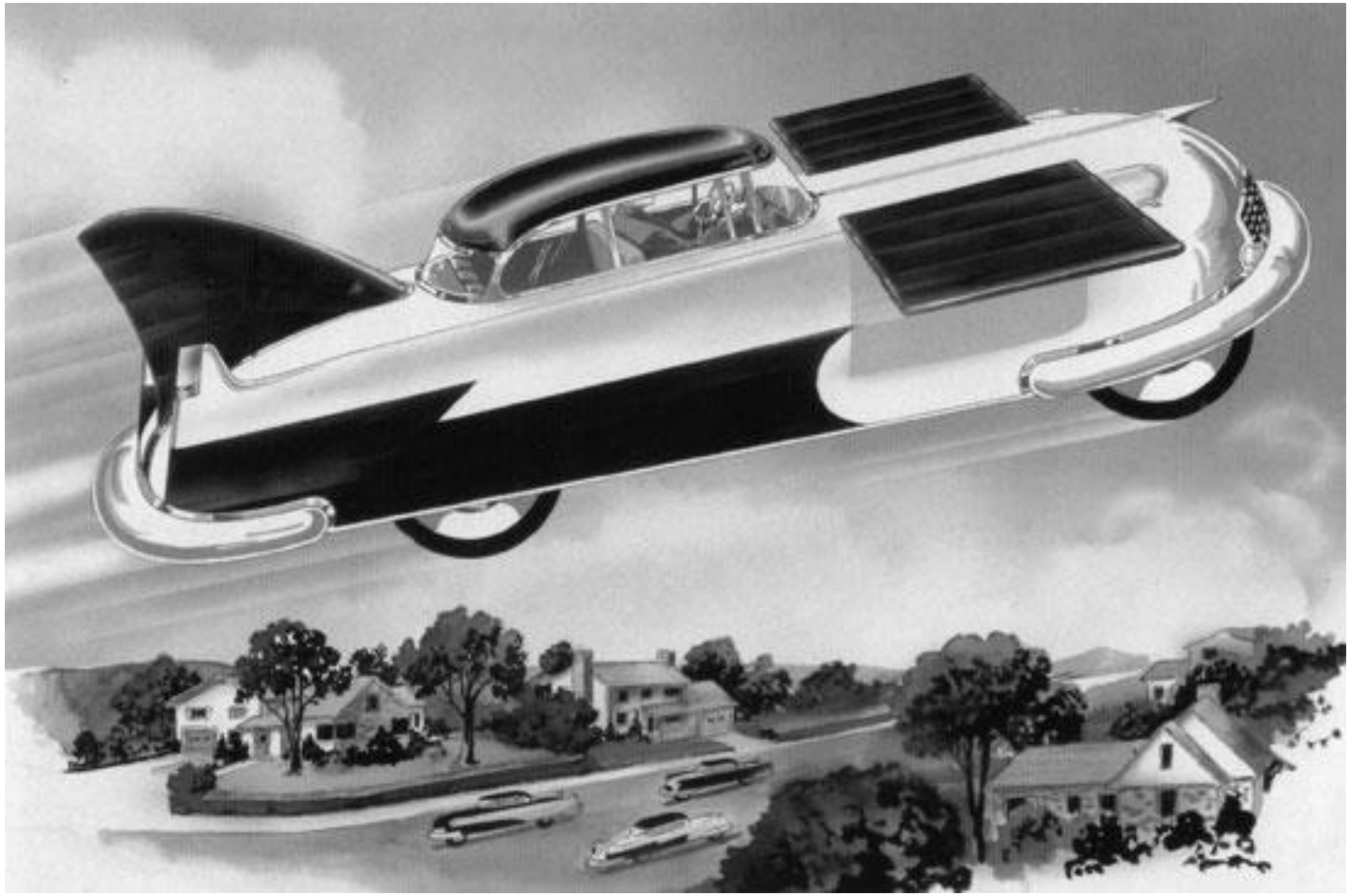
- Autonomous driving challenges
- Machine learning
- Supporting technology
- Safety, security and resilience

ADAS evolving to autonomy

ADAS		Autonomous		
Level 1	Level 2	Level 3	Level 4	Level 5
Driver Assistance	Partial Automation	Conditional Automation	High Automation	Full Automation
Everything On	**Feet Off**	**Hands Off**	**Eyes Off**	**Mind Off**
2000	2013	2018	2024	2027

In the future my self-driving car will whisk me to work at 80mph!

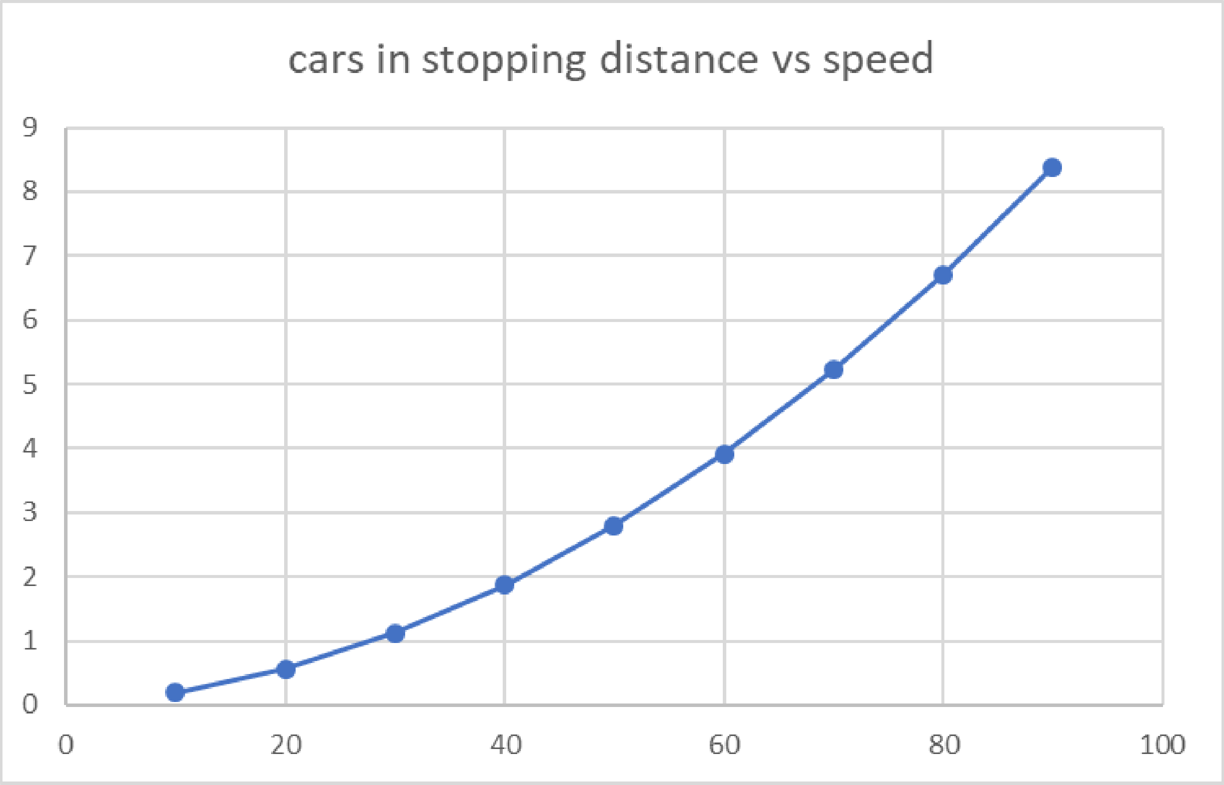
- And it will pay for itself by operating as a taxi while I'm at work!



No it won’t.

Speed is expensive

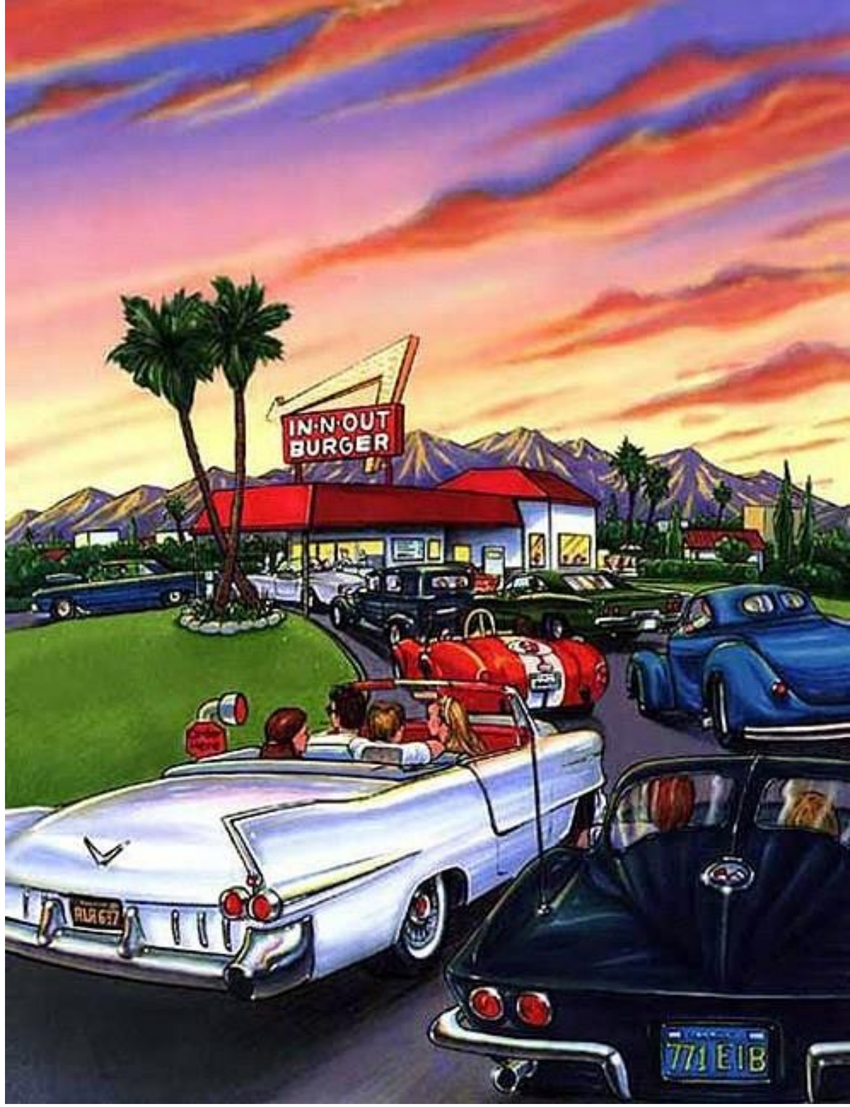
- More energy
- More complexity
- Less margin



Car culture

"Climbing up that Grapevine hill,
passing cars like they was standing still"
- Charlie Ryan, Hot Rod Lincoln

- Why do we pass other cars?
- Should we?
- Should we build autonomous systems that enable our antisocial behavior?



Source: In-n-out burger

Avoiding trolley problems

- Self-driving systems need to be ethical
- Need to address the right question

Source: Wikipedia

Automated driving: Interstate 5

- Task: pass trucks
- Speed: 70mph
- Relevant objects: 10-20
- Confounding challenges
  - Trucks passing each other
  - Right lane bandits
  - Motorcycles
  - Exits/onramps
  - Road construction
  - Accidents, breakdowns
  - Emergency vehicles
  - Wildlife
  - Weather, darkness

Automated driving: John Bull Trail

- Task: get over obstacles
- Speed: 0-2 mph
- Relevant objects: <10
- Confounding challenges
  - Rocks
  - Trees
  - Holes
  - Mud
  - Breakdowns

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Automated driving: Highway 101

- Task: Get to your exit
- Speed: 0-65 mph
- Relevant objects: 50-100
- Confounding challenges
  - Too many cars, too little road
  - Accidents, breakdowns
  - Motorcycles
  - Emergency vehicles
  - Exits/onramps
  - “idiots” and “maniacs”
  - Construction
  - Weather, darkness
  - Random events

Automated driving: Second Avenue

- Task: Get where you turn
- Speed: 0-25 mph
- Relevant objects: 200+
- Confounding challenges
  - Jaywalkers, bicyclists, dogs, etc.
  - Cars, motorcycles, scooters
  - Traffic lights
  - Parking
  - Buses
  - Delivery trucks
  - Tourists
  - Construction
  - Emergency vehicles
  - Accidents
  - Weather, darkness

Flickr photo: Oran Viri

Automated driving: Parking lot

- Task: Find a spot
- Speed: 0-5 mph
- Relevant objects: 200+
- Confounding challenges
  - Unclear rules
  - Cars backing up
  - Pedestrians
  - Shopping carts
  - Children, pets
  - Motorcycles, bicycles, trucks
  - Weather, darkness

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How do you solve the parking lot problem?

- You don't

Canonical system

- Increasing number of objects
- Increasing complexity of task
- Increasing number and complexity of challenges

A picture containing road, sky, outdoor, building

- Merging diverse sensor content to achieve "perception"
- Context is hard in the cloud
- It's harder in real time in a car

The importance of feedback

- Labeled training sets
- Reinforcement learning
- Adversarial learning

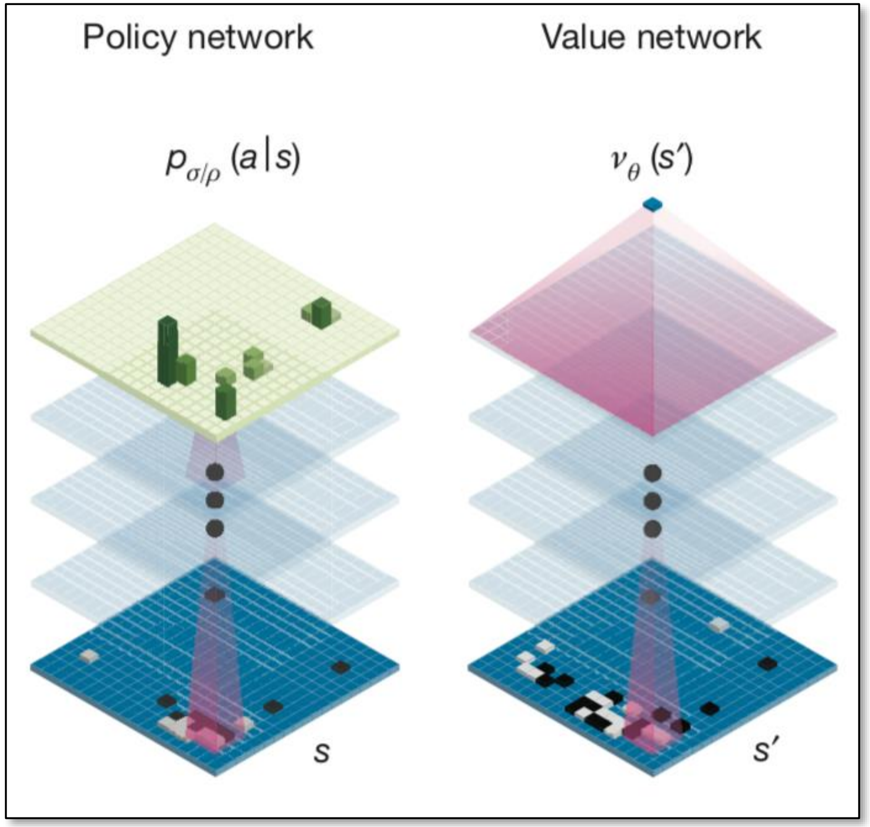
Source: NVidia

ML can beat champion Go players

- But how will it do playing with a 4 year old?

AI Challenges: Calvinball vs Go

Source: GoComics.com



Source: Nature, 2016

Complex problem classes

Go Problems

- Fixed goal
- Fixed rules
- Fixed interpretation of the rules
- Replay game, same results

Calvinball Problems

- Goal keeps changing
- Rules keep changing
- Interpretation of rules keeps changing
- Replay game, different results

David Marr’s “Personal View” of AI, 1977

- Type 1 theory (“clean”): The problem has a method to solve it; i.e. a known way of stating what the problem is and what the solution looks like
- Fourier transform, Go

- Type 2 theory (“messy”): The problem does not have a type 1 theory; e.g. a problem that is solved by the simultaneous interaction of a large number of processes, whose interaction is its own simplest description
- Protein folding, Calvinball

- “The principle difficulty in AI is that one can never be sure whether a problem has a type 1 theory”

Is driving Calvinball or Go?

Science

Google promises autonomous cars for all within five years

New California law clears driverless cars from 2015

By Iain Thomson in San Francisco 25 Sep 2012 at 23:13 108 SHARE ▼

The Register, Sept 25 2012

GM's Driverless Vehicles Require a 'Degree of Harmonization' With Governments, Innovation Chief Says

Fortune, Oct 15, 2018

Chicago, Oct 14, 2017

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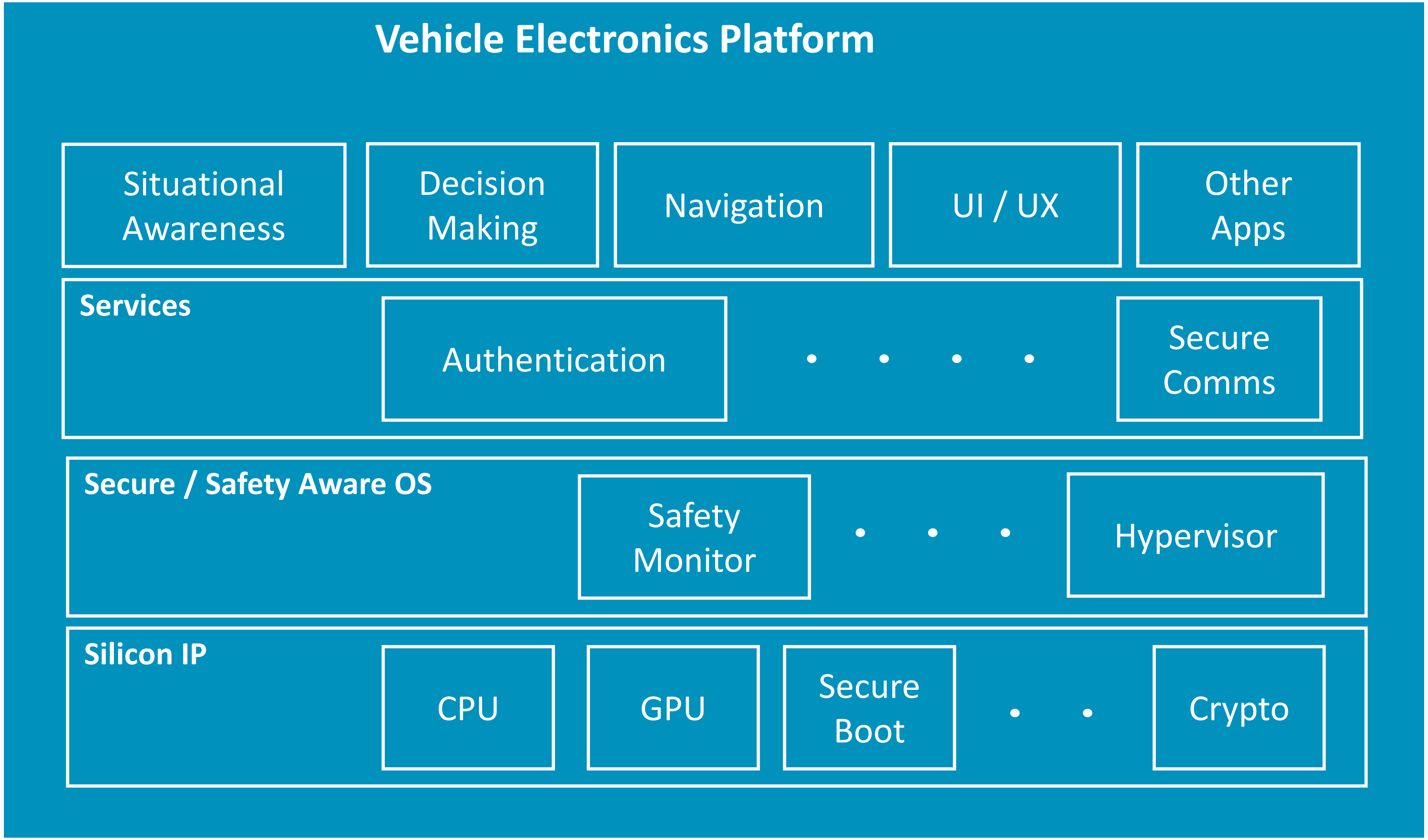
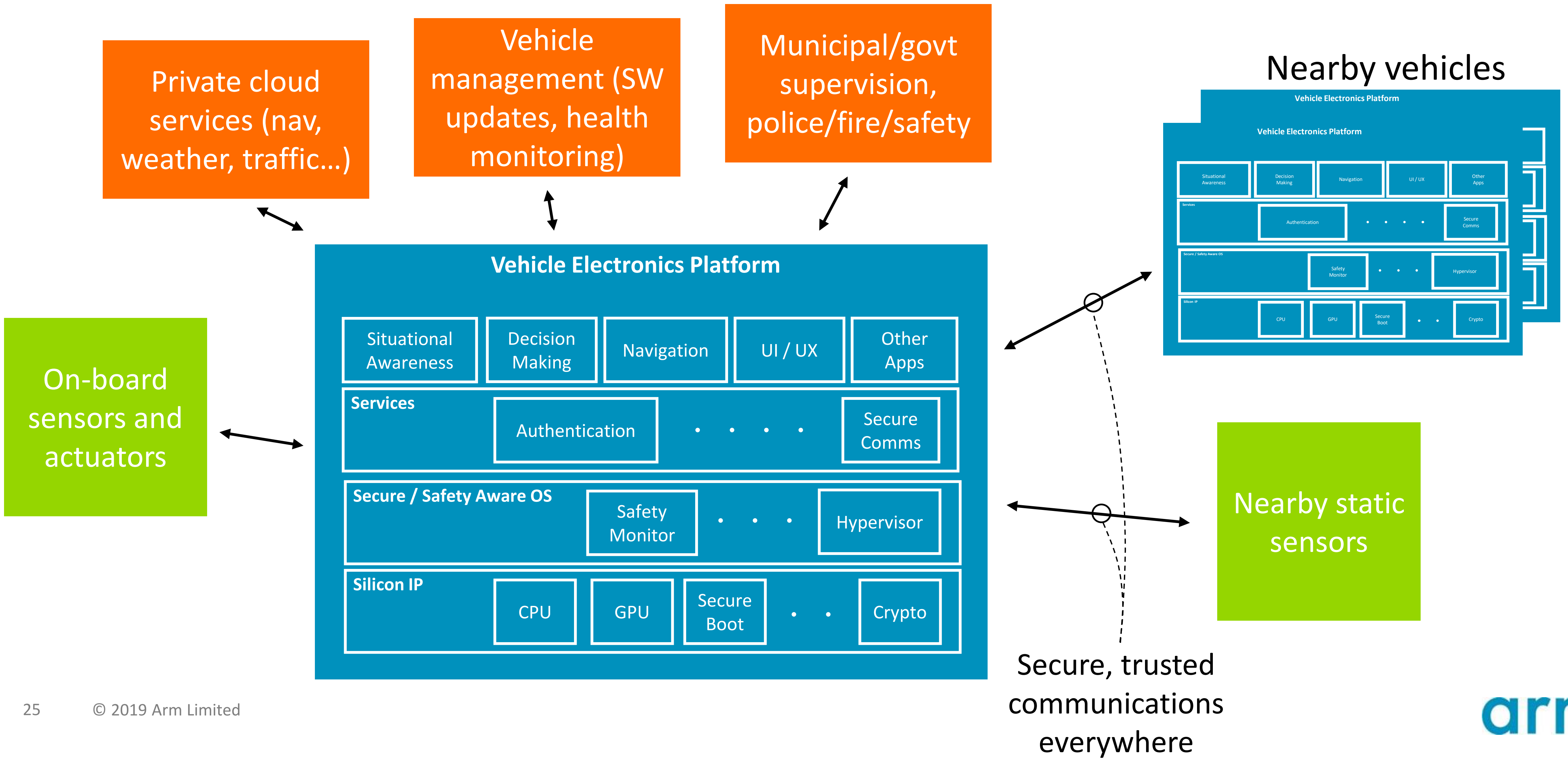
Avoiding Calvinball by moving the goalposts

- Simplify problem
- Define (or declare) a fixed-complexity subset of the hard problem to be important
- Define a metric for success
- Build solution
- Iterate and make solution (and metric) better

We think about the canonical vehicle stack



…but the system is much more complicated than that



Automotive dystopia? No autonomy for you

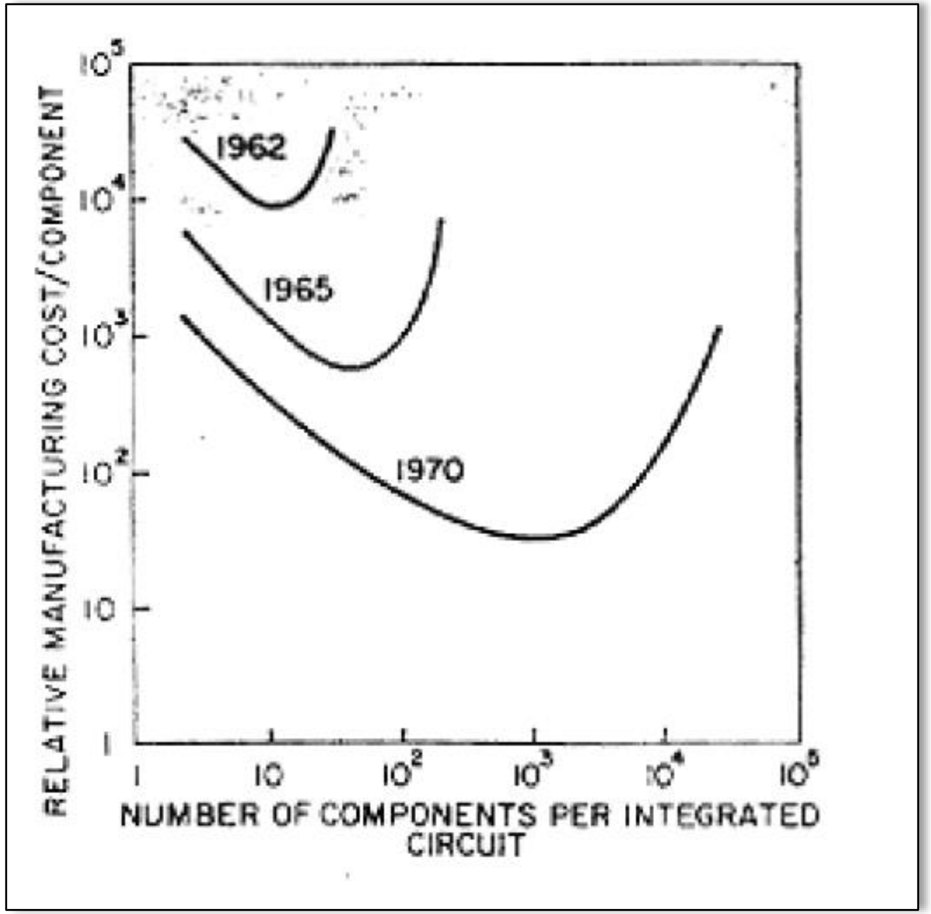
- The more autonomy your car has, the less you have, at least as far as driving is concerned
- All other transport systems operate with centralized control points (planes, trains, ships, etc.), for reasons of safety and efficiency
  - You only go when told you can vs you can go unless told you can't
- You decide where you want to go and how much you're willing to pay
- The system decides what route you take and when you get there

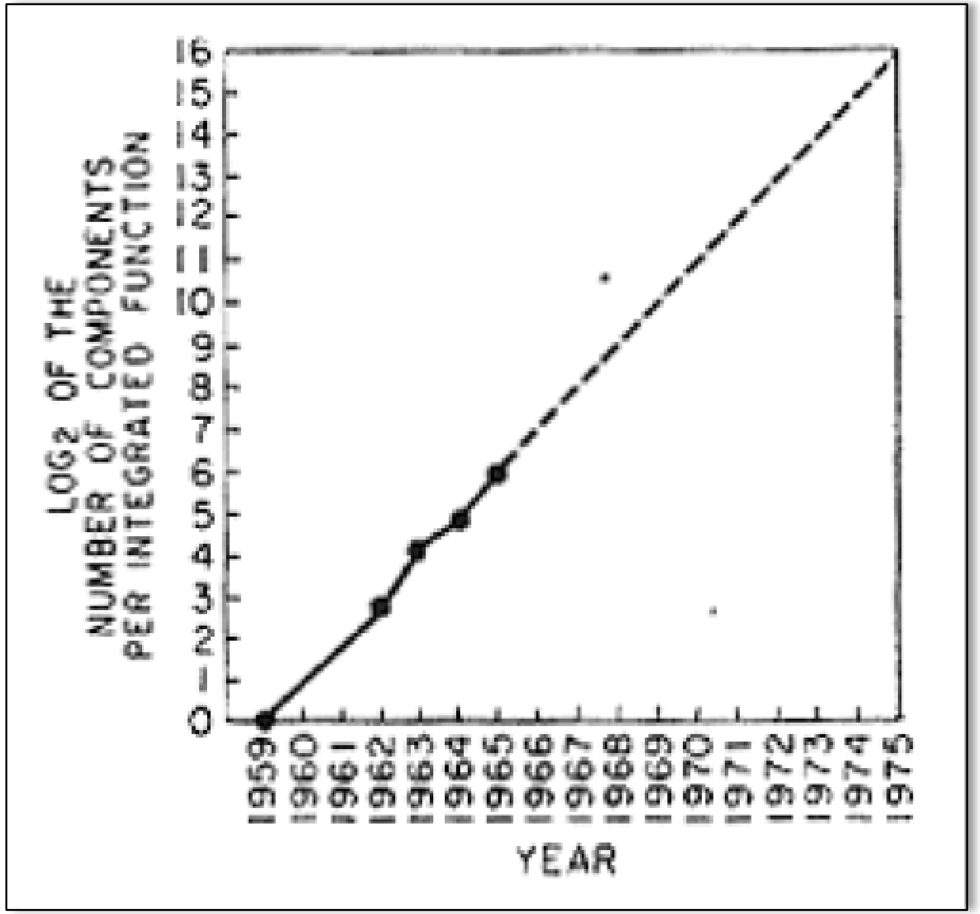
Design issues

- L3 systems use kW of power and fill the trunk
- L4 and L5 need more compute horsepower
- Design for performance, energy, weight…
- Also resilience, safety, security…

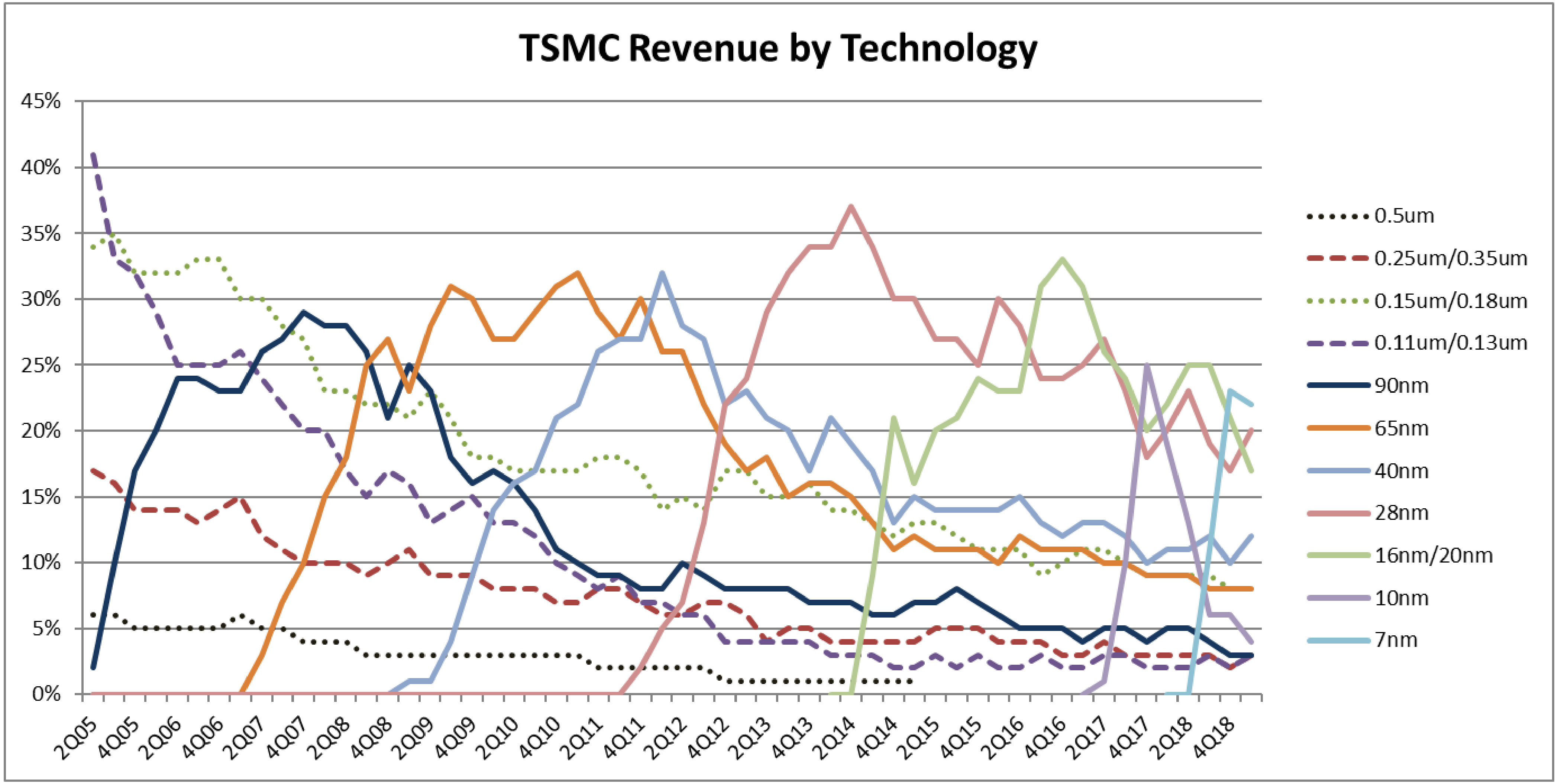
Source: Nissan via Furono ITS Journal

You knew we would get to Moore's law…





The State of Moore's Law



Data source: TSMC reports

The brakes are on

- Node cadence slowing
- Node feature scaling slowing
- FinFETs run out of gas soon
- 3D is promising, but 3D is linear
  – Moore is exponential
- Post-CMOS options range from
  “wildly improbable to impossible”
  -Anonymous research fab engineer

Moore Café

Technology Menu

Choose any ~~two~~ *one*

Faster!

Smaller!

Lower power!

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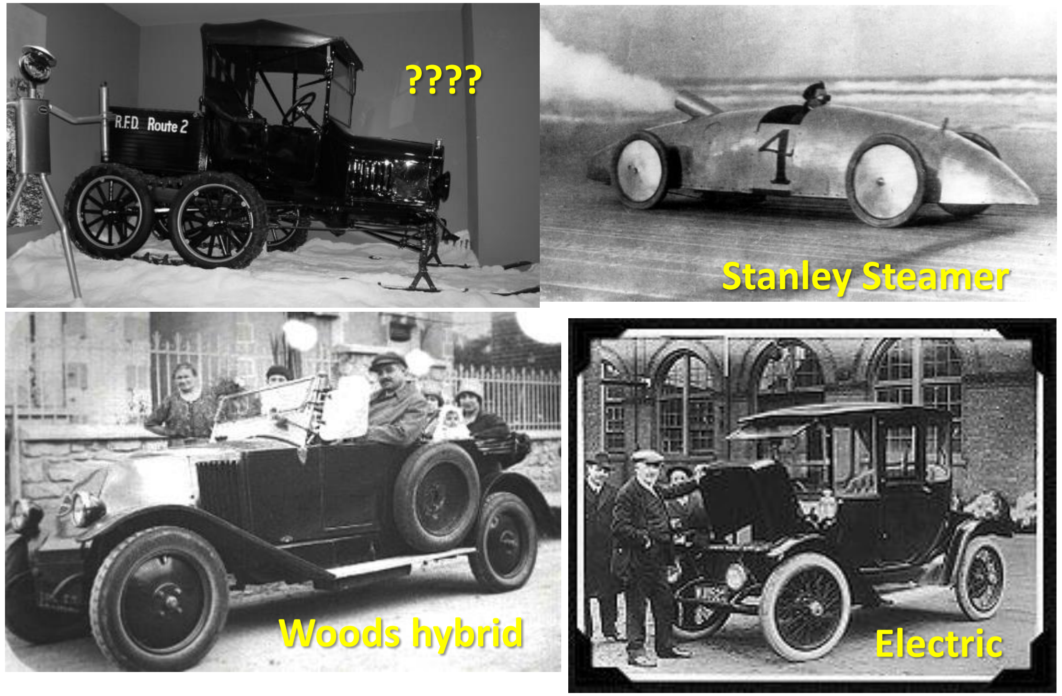
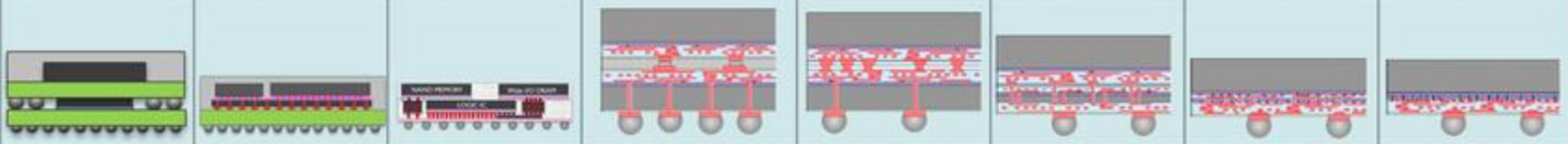
Disruptive technologies: diversity leads to uniformity



- Initially wide variety of creative solutions to a problem
- Some of these do better than others, eventually leading to uniformity
  - Still creativity, but focused on details
- Change in underlying problem can bring about new creative era

The 3D landscape

	3D-SIP			3D-SIC	3D-SOC			3D-IC
3D Technology	"PoP"	"Chip last"	"Chip first"	Die stacking	Parallel W2W		Sequential FEOL	
3D-Wiring level	Package I/O	Chip I/O Interposer I/O	Chip I/O	Global	Semi-global	Intermediate	Local	FEOL
				Chip BEOL Wiring Hierarchy				
Partitioning	Functional unit	subsystem	Embedded die	Die	Blocks of standard cells		Standard cells	Transistors
Technology	Package-to Package reflow	Multi-die SIP 3D/2.5D stack	FO-WLP Embedded die	3D D2D, D2W 2.5D Si-interposer	Wafer-to-Wafer bonding Hybrid bonding	Via-last	Active layer transfer or deposition	
2-tier stack Schematic								
Characteristic	Solder ball Stack	• C4, Cu-pillar Si-Organic • Through-Mold-vias	• Bumpless • Si-RDL • Through-Package-vias	• µbump • Si-to-Si • Through-Silicon-Via	BEOL between 2 FEOL layers			FEOL stack
					Overlay 2nd tier defined by W2W alignment/bonding		Overlay 2nd tier defined by litho scanner alignment	
Contact Pitch	400⇒350⇒300µm	120⇒80⇒60µm	60 ⇒40 ⇒20µm	40 ⇒20 ⇒10⇒5µm	5µm ⇒ 1 µm	2 µm ⇒ 0.5 µm	200nm ⇒ 100nm	< 100 nm
Relative density:	1/100⇒1/77⇒1/55	1/9⇒1/4⇒1/2.3	1/2.3 ⇒ 1 ⇒ 4	1 ⇒ 4 ⇒16⇒ 64	64 ⇒ 1600	400 ⇒ 6400	$4\ 10^4$ ⇒ $1.6\ 10^5$	> $1.6\ 10^5$

Source: IMEC via Electronics Weekly, Jan 18

Something is going to win

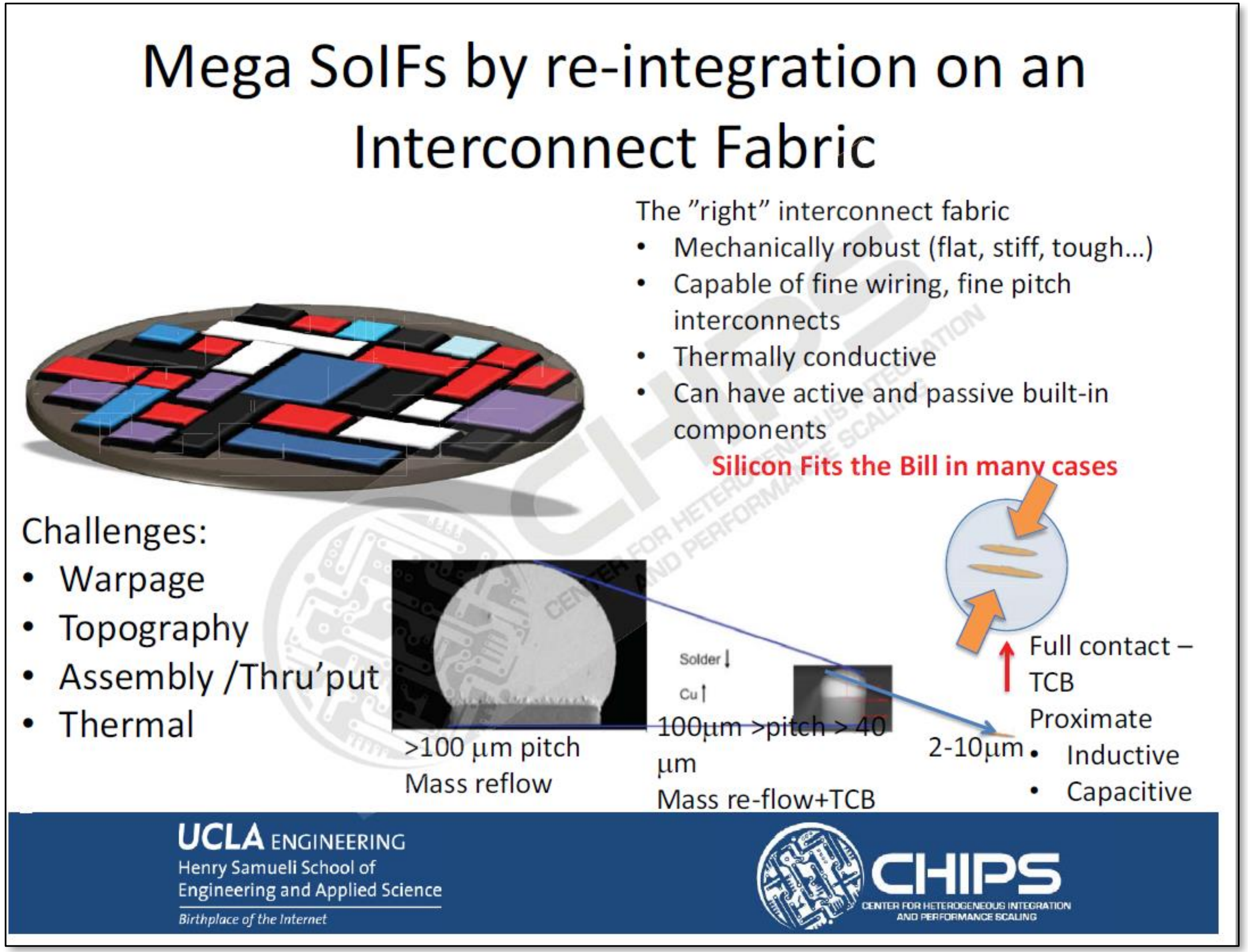
We just don't know precisely what…

Some likely features

- Scalable, modular design
- Commercial EDA support
- Heterogenous compute
- Solution to memory bottleneck
- Solution to I/O bottleneck
- Reasonable answers on test, yield etc.

One candidate: “Wafer scale” integration

- Subu Iyer et al at UCLA
- Get rid of packages and use a silicon substrate for dense high performance interconnect



What is Functional Safety?

“Absence of unreasonable risk due to hazards caused by malfunctions”

ISO 26262

Systems must function correctly
- Systematic capability
- Diagnostic capability

Safety “nominal”

Safety critical

Types of Fault

Random faults

- Hard errors
- Soft errors
- Permanent faults
- Transient faults
- Latent faults

Managed by including features for fault detection and control

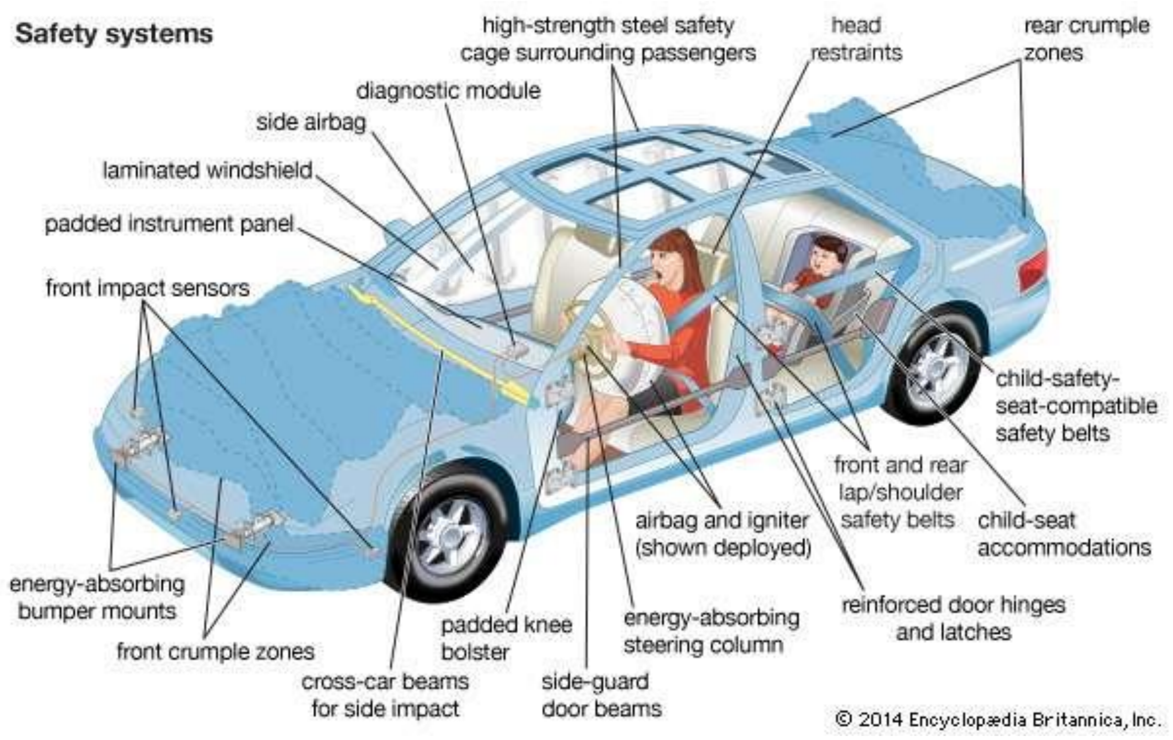
Systematic faults

- Hardware errata
- Software bugs
- Incorrect specification
- Incomplete requirements
- Unfulfilled assumptions

Managed through design process, verification and assessment

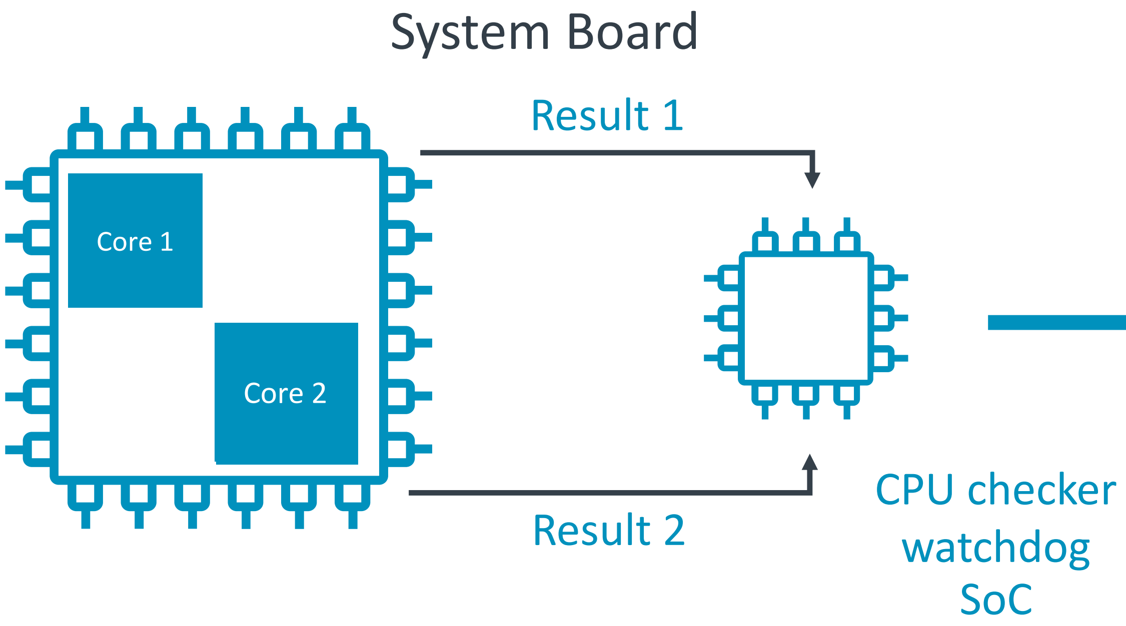
Safety, resilience and security

- Safety needs to be designed in
- Can solve problems at multiple layers
- Answers not always obvious



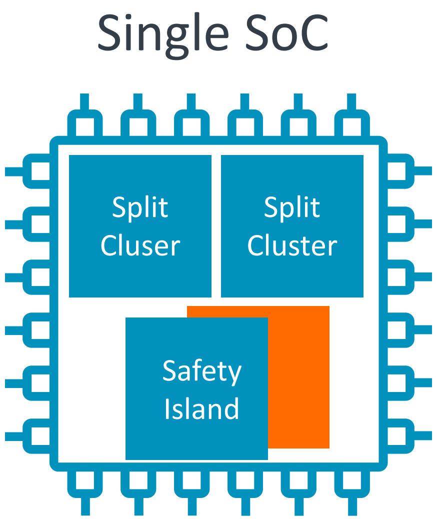
Safety Island

Typical Redundancy Implementation



- Inefficient fixed architecture
- Decoupled fault detection & control
- Complex certification
- More board space, higher power

Flexible Split-Lock



- Efficient & integrated
- Faster more capable reaction to errors
- Simplified software
- Simplified certification and supply chain

Cross-layer reliability

- Physical sensors, connectors, processors, radios
- Software at each stage
- Time redundancy vs space redundancy
- Fault tolerant systems & systems of systems

Safety, resilience and security

- Overall objective related
- Some details can be challenging

Summary

- Automotive is a key challenge and opportunity for industry
- Safety, security and resilience bring new challenges to machine learning
- Moore's law matters and will influence what will be built
- 3D techniques provide a way forward

Thank You
Danke
Merci
谢谢
ありがとう
Gracias
Kiitos
감사합니다
धन्यवाद
شكرًا
תודה