Digital Transformation in the Automotive Industry

Digitale Transformation in der Automobilindustrie

Dr. Michael Nolting

Lecture 10

Tutorials

- Homework will be reading the book from Gene Kim „The Phoenix Project"

The homeworks are optional and not relevant for the exam

Lecture Overview

1. Introduction: Why Digital & Data Transformation	**7. Culture & Organization**
Homework 1: Reading 60 mins the Phoenix Project	Homework 7: Reading 60 mins the Phoenix Project
2. The World is Changing: ACES & VUCA	**8. Examples of Digitalization Projects I**
Homework 2: Reading 60 mins the Phoenix Project	Homework 8: Reading 60 mins the Phoenix Project
3. The Technological Disruption	**9. Examples of Digitalization Projects II**
Homework 3: Reading 60 mins the Phoenix Project	Homework 9: Reading 60 mins the Phoenix Project
4. Challenges for the Transformation - Innovation	**10. TESLA as THE Digital Player**
Homework 4: Reading 60 mins the Phoenix Project	Homework 10: Reading 60 mins the Phoenix Project
5. Challenges for the Transformation - Legacy	**11. Q & A – Exam**
Homework 5: Reading 60 mins the Phoenix Project	
6. How to Transform Into a Techgiant	
Homework 6: Reading 60 mins the Phoenix Project	

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Agenda

01	**Tesla's Fleet**
02	Tesla's Production Secret
03	Tesla's Mindset
04	Summary
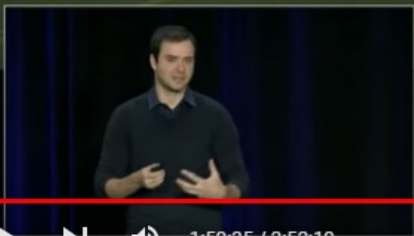
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THE LARGER THE MORE ACCURATE

Fraction of Data	Hours	Regular Dev	Noisy Dev
1%	120	29.23	50.97
10%	1200	13.80	22.99
20%	2400	11.65	20.41
50%	6000	9.51	15.90
100%	12000	8.46	13.59
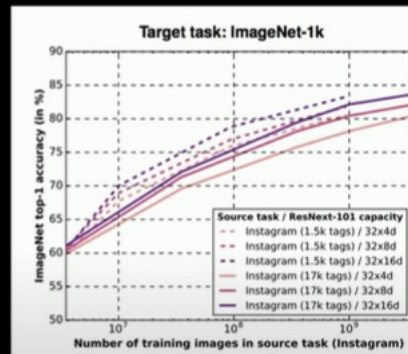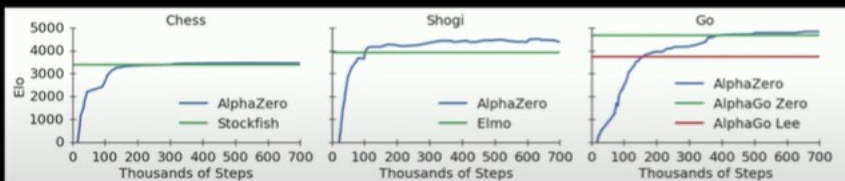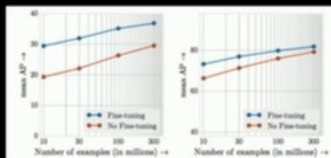
[1] Sun et al., Revisiting Unreasonable Effectiveness of Data in Deep Learning Era
[2] Amodei et al., Deep Speech 2: End-to-End Speech Recognition in English and Mandarin
[3] Mahajan et al., Exploring the Limits of Weakly Supervised Pre-training
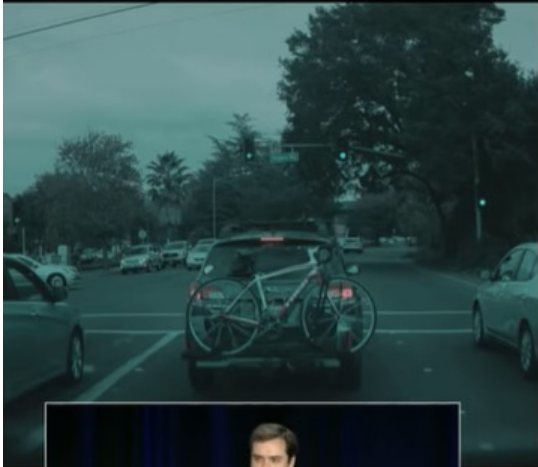[4] Silver et al., Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm

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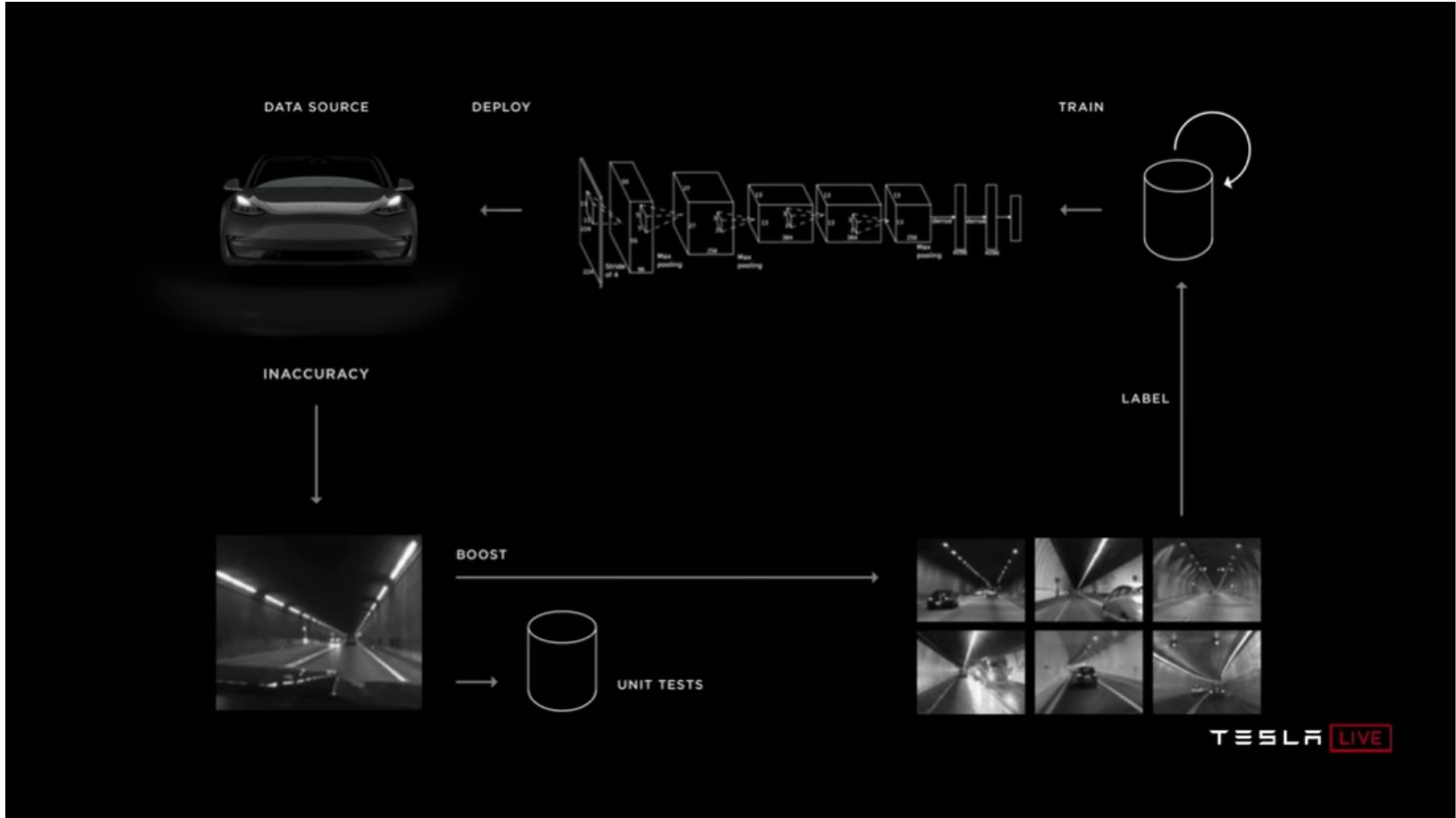
FLEET LABELING DATA AUTOMATICALLY
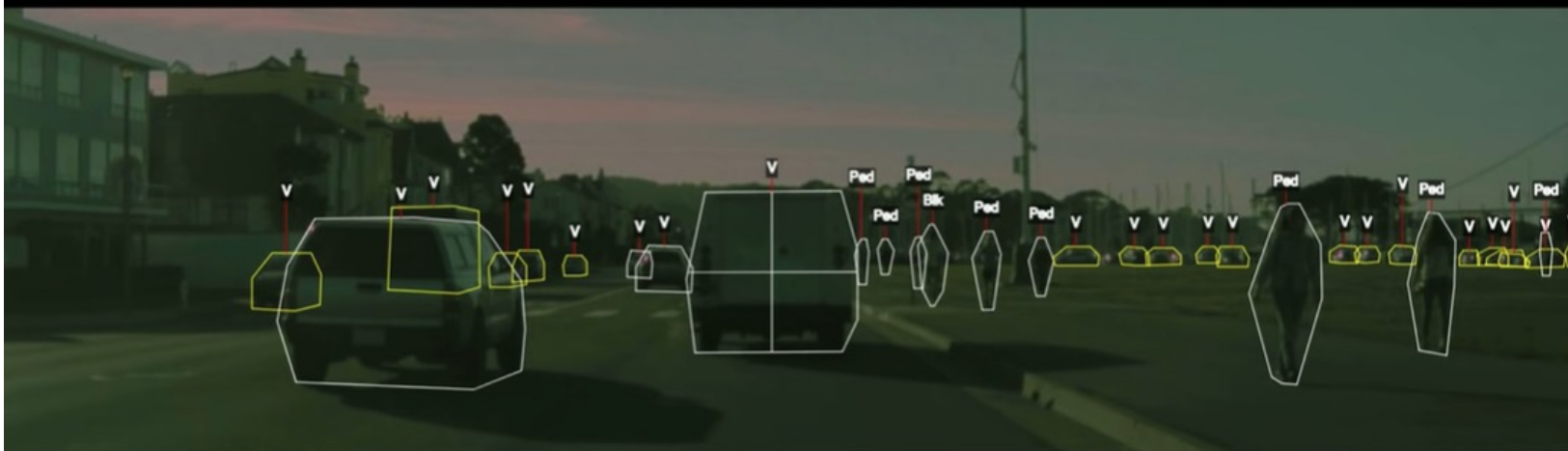
Human annotation is expensive   Labels can be obtained automatically

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FLEET LEARNING: CUT-INS
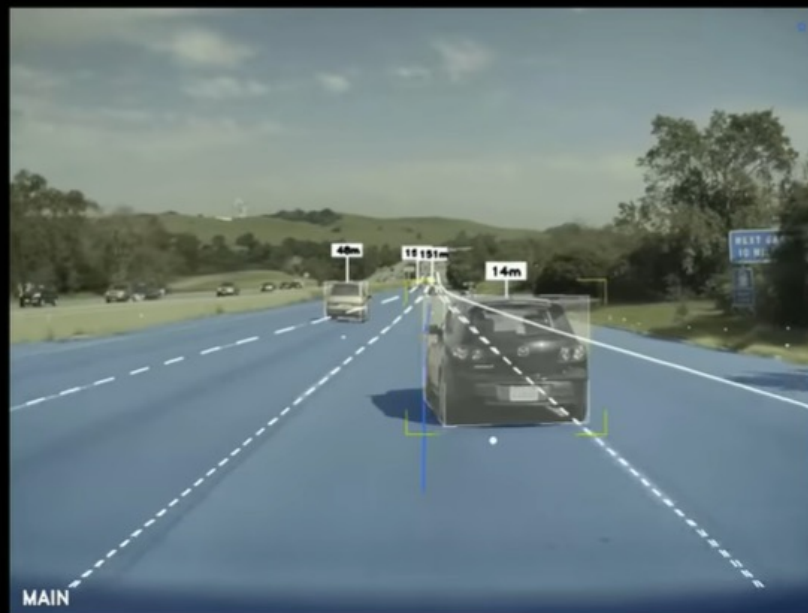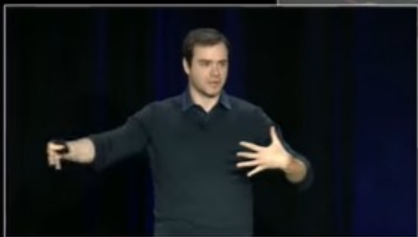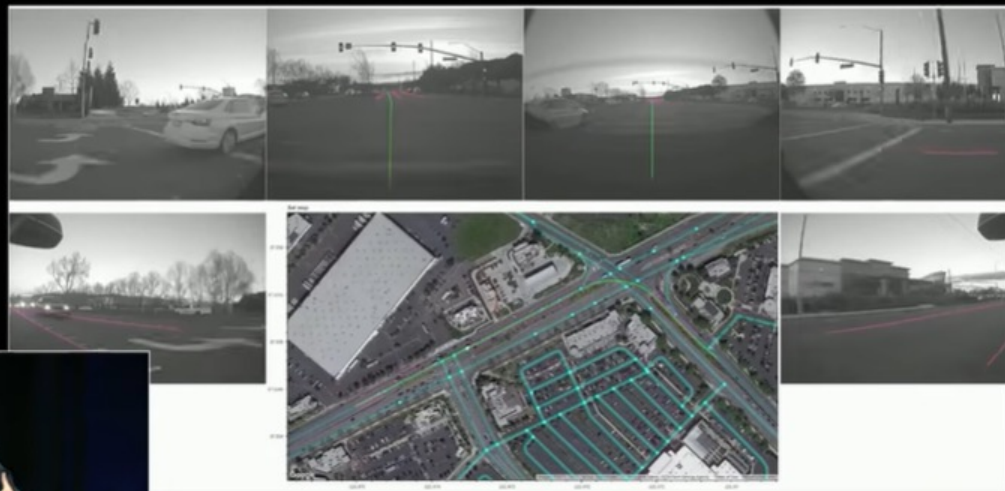
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PATH PREDICTION

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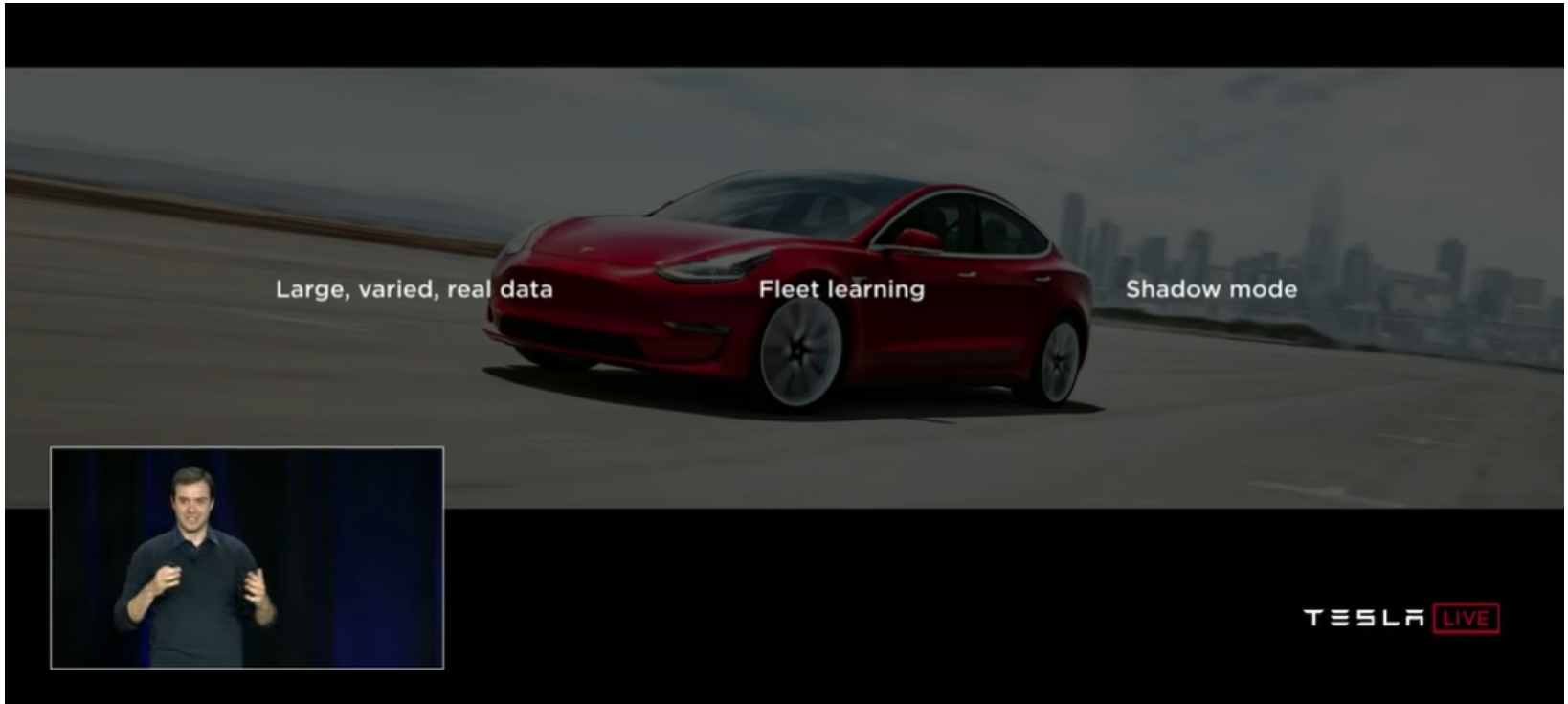
Business

A glimpse into the self-driving future

JACKSONVILLE, FLA.

Riding along in a Tesla, a reporter learns that true autonomy is years away

BY CADE METZ
AND BEN LAFFIN

When we decided it was time for lunch, Chuck Cook tapped the digital display on the dashboard of his Tesla Model Y and told the car to drive us to the Bearded Pig, a barbecue joint on the other side of town.

"I don't know how it's gonna do. But I think it's gonna do pretty good," he said with the folksy, infectious enthusiasm he brought to nearly every moment of our daylong tour of Jacksonville, Fla., in a car that could drive itself.

For more than two years, Tesla has been testing a technology it calls Full Self-Driving with Mr. Cook, a 53-year-old airline pilot and amateur beekeeper, and a limited number of car owners across the United States.

Tesla has long offered a driver-assistance system called Autopilot, which can steer, brake and accelerate its cars on highways.

But Full Self-Driving is something different. It is an effort to extend this kind of technology beyond highways and onto city streets.

This summer, Elon Musk, the company's chief executive, said the system would be available in more than a million cars by the end of the year. In August, we spent a day driving around with Mr. Cook and his Tesla to assess the progress of this experimental technology.

Over six hours, his car navigated highways, exit ramps, city streets, roundabouts, bridges and parking lots. With Mr. Cook's hands near or on the wheel and his eyes on the road, the car attempted more than 40 unprotected left-hand turns against oncoming traffic. It kept us on the edge of our seats.

THE JOURNEY TO THE BEARDED PIG

The most telling moment came as the car drove us to lunch. After navigating heavy traffic on a four-lane road, taking an unexpected turn and quickly remapping its route to the restaurant, the car took a right turn onto a short street beside a small motel. But as the Tesla struggled to make sense of its environment, veering from the road into a motel parking lot, Mr. Cook had to retake control.

After driving around the motel, the car almost immediately made the same mistake, jerking into the lot this time. It was sobering to see how close we came to hitting a parked car after we rolled over a low curb separating the parking lot from the road. Even the car's internal display suggested that the car was struggling to distinguish the curb.

Tesla is constantly modifying the technology, working to fix its shortcomings. Since the day we drove around Jacksonville, the company has twice released new versions of the technology that show signs of improvement. But the moment in the motel parking lot showed why it may be a long time before cars can safely drive anywhere on their own.

The experiences of beta testers like Mr. Cook are a window into the enormously ambitious and expensive bet that Tesla is making on self-driving technology.

It and other companies are investing billions in researching and developing autonomous vehicles — taxis that can ferry us around town, trucks that will deliver our online orders and maybe even one day cars that will take our children to soccer practice.

Elon Musk and Tesla did not respond to requests to participate in this story. But Mr. Cook's Model Y provides a glimpse of the future we are moving toward, which may prove to be safer, more reliable and less stressful — but is still years away from reality.

Tesla's technology can work remarkably well. It changes lanes on its own, recognizes green lights and is able to make ordinary turns against oncoming traffic. But every so often, it makes a mistake, forcing testers like Mr. Cook to intervene.

Experts say no system could possibly have the sophistication needed to handle every possible scenario on any road. This would require technology that mimics human reasoning — technology that we humans do not yet know how to build.

Such technology, called artificial general intelligence, "is still very, very far away," said Andrew Clare, chief technology officer of the self-driving vehicle company Nuro. "It is not something you

For more than two years Chuck Cook has been testing a technology that Tesla calls Full Self-Driving. Sometimes the car performs perfectly, and sometimes it loses its bearings.

IAN CLONTZ FOR THE NEW YORK TIMES

> "The technology is not ready to take the driver out of the seat. As they continue to iterate on the hardware and the software, it is like a salmon going up river."
>
> CHUCK COOK, a 53-year-old airline pilot and amateur beekeeper who has been testing Tesla's Full Self-Driving technology

or I or our kids should be banking on to help them get around in cars."

"CHUCK'S TURN"

In the tight-knit community of Tesla enthusiasts, stockholders, bloggers and social media mavens, Chuck Cook is famous. This summer, Mr. Musk noticed the meticulous way he explored the boundaries of the technology in a series of YouTube videos.

Mr. Cook had been posting online clips of his Tesla trying to navigate an unprotected left turn near his home in Jacksonville. To make this turn, the car must pass through three lanes of traffic approaching from the left, squeeze through a gap in the median and merge into three more lanes of traffic approaching from the right.

Sometimes, the car made the turn with aplomb, edging into the thoroughfare and waiting for a moment when it could speed into a far lane. Other times, it got stuck beside the median in the middle of the turn — its rear bumper jutting into the oncoming traffic.

Soon, Mr. Musk noticed the videos and vowed to solve what Tesla enthusiasts began calling "Chuck's turn." In the weeks that followed, Tesla equipped several test cars with a new version of its self-driving technology and sent them to Mr. Cook's neighborhood, where they spent several weeks testing the new software and gathering data that could help improve it.

Mr. Cook and I spent a good chunk of our day asking his car to navigate the turn named after him. Each attempt was different from the last. Sometimes, the cars approached much faster from the left. Other times, from the right. Sometimes, the gap between the two was enormous. Other times, it was tiny.

Not long after that day in Jacksonville, Tesla released a new version of its software to Mr. Cook and other beta testers.

The car's display now showed a blue overlay that indicated what was a safe zone in the median. When facing heavy traffic, it could navigate Chuck's turn with a precision that had not been possible in the past. So if it needed to stop next to the median, it would position it-

self so that traffic could safely pass both in front and behind.

Chuck's turn is just one scenario among the endless scenarios a Tesla might face on roadways.

Some are relatively common. Companies like Tesla can test and retest their technologies in these situations until they are confident a car can handle them safely. But other scenarios are rare and unexpected — what industry experts call "edge cases."

"It is very easy to solve the first 90 percent of the problem, very hard to solve the last 10 percent," Mr. Clare said, referring to the decades-long effort to create self-driving cars. "You need to be able to handle those edge cases gracefully."

FACING THE UNEXPECTED

When Mr. Cook told the car to drive us to a small neighborhood park near the river, the skies were overcast and the streets were wet from summer rain.

Guided by Tesla's self-driving technology, the car drove along the river and over a bridge before reaching an intersection lined with trees. Then it turned left toward an unmarked road that ran between several giant oaks draped in Spanish moss.

As the car approached the shadows beneath this mossy canopy, it suddenly changed course, turned sharply right and headed the wrong way down a one-way street.

The moment highlighted the difference between Tesla's self-driving technology and "robotaxi" services being developed by companies like Waymo, owned by the same parent company as Google, and Cruise, backed by General Motors.

The robotaxi companies are trying to reduce these unexpected moments by tightly controlling where and how a car can drive. Using laser sensors called lidar, they build three-dimensional digital maps of individual neighborhoods that give cars a fine-grained understanding of their environment. Then they spend months or even years testing cars in these contained areas.

These companies are now preparing self-driving car services that will operate without backup drivers in places like San Francisco and Austin, Texas. But these services will have strict limitations that make the task easier. The cars will travel only in certain neighborhoods under certain weather conditions at relatively low speeds. And company technicians will provide remote assistance to cars that inevitably find themselves in situations they cannot navigate on their own.

Tesla is not operating in this way. Lidar sensors are too expensive for most consumer vehicles. Building three-dimensional maps and testing vehicles on every American roadway is impractical. So is remote assistance. This means that Tesla cars face the unexpected more often than Waymo or Cruise cars — and that testers like Chuck Cook must keep their hands on the wheel at all times.

Just last week, he and his car revisited a few of the scenarios we encountered in August.

Sometimes the car performed perfectly. Sometimes it did not. It drove past the motel on the way to the Bearded Pig six times, and though it remained on the road three times, it mistakenly drove into the parking lot three times as well.

When it did veer into the parking lot, it did not swerve as egregiously as it did in August. Mr. Cook says he is impressed with the progress of the technology.

But he also knows that far more progress is needed. He also knows that Tesla engineers are focused on the behavior of his car and that others may not perform as well in situations that have not been closely scrutinized.

"The technology is not ready to take the driver out of the seat," Mr. Cook told me on a recent morning. "As they continue to iterate on the hardware and the software, it is like a salmon going up river."

After releasing the new beta, Mr. Musk softened his claims about the immediate future of the technology. He now says that the technology will not be widely available until next year — and that regulators are unlikely to approve it for use without hands on the wheel. Autopilot still requires this oversight.

Federal regulators have spent the past several months investigating a series of crashes involving Autopilot, and they have not yet revealed the results. Safety experts worry that the arrival of Full Self-Driving will lead to more accidents.

"It is inevitable," said Jake Fisher, senior director of Consumer Reports' Auto Test Center, who has used the technology. "The problem comes as this system gets better and people get complacent. It will still do the unexpected."

Agenda

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Tesla's Fleet
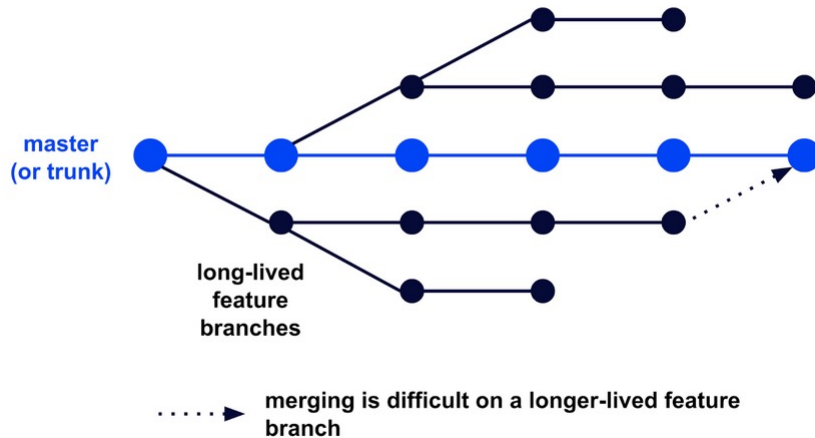
Tesla's Production Secret

Tesla's Mindset

Summary

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Tesla's secret #1
Trunk-based Development in the Production – or – mastering the hell of SOPs

Feature-branched development

master (or trunk)

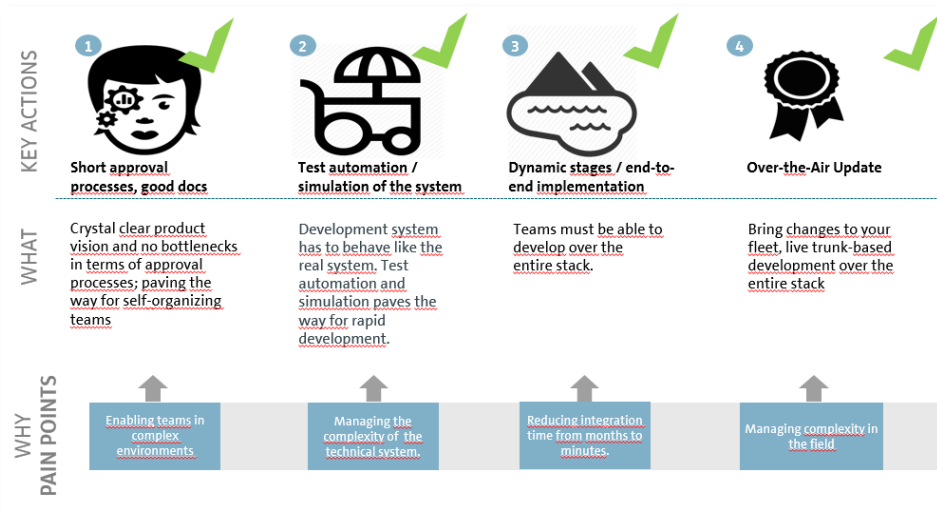long-lived feature branches

······▶ merging is difficult on a longer-lived feature branch

- Why trunk-based development is heavily used by all tech giants such as Amazon, Google, Facebook, Netflix etc.?
  - It reduces complexity by merging early
  - It reduces complexity by keeping heterogeneity small
  - It speeds up deployments and pays in on customer centricity

- How does Tesla leverage this design pattern from software development in the production?
  - Production is seen as trunk
  - All changes are immediately applied to the production line
  - No production-like „feature branches" (in our cased SOPs of different car models) are created; any change goes directly to the production line (APIs in the cars are stable, OTA-updates are applied to previously produced cars)

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Tesla's secret #2
No complex agile methods – or – just get the shxx done

KEY ACTIONS	**1** Short approval processes, good docs	**2** Test automation / simulation of the system	**3** Dynamic stages / end-to-end implementation	**4** Over-the-Air Update
WHAT	Crystal clear product vision and no bottlenecks in terms of approval processes; paving the way for self-organizing teams	Development system has to behave like the real system. Test automation and simulation paves the way for rapid development.	Teams must be able to develop over the entire stack.	Bring changes to your fleet, live trunk-based development over the entire stack
WHY PAIN POINTS	Enabling teams in complex environments	Managing the complexity of the technical system.	Reducing integration time from months to minutes.	Managing complexity in the field

TESLA's secret weapons for enabling agile teams without using agile methods such as SAFEScrum

- Why do we use complex agile methods such as SAFEScrum etc.?
  - To master complexity between separate teams
  - To master the complexity of enterprise processes (such as financing etc.)
  - To master the complexity of determining what to do (sticking to the backlog, „low pass filtering" on decisions)

- Does TESLA use SAFEScrum or any other agile method?
  - No, they support ad-hoc cross-functional team building:
    - Backlog is organized according the vision KPIs
    - Each and every team has the goal to improve a KPI within 3 hours (if not the team dissolves)

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Tesla's secret #3
Eliminating all bottlenecks which matter

Bottlenecks and Their Impact

$$Wait\ Time = (\%\ Busy)/(\%\ Idle)$$

(Graph: Wait Time vs. % Resource Busy, with "Wait Time" series marked)
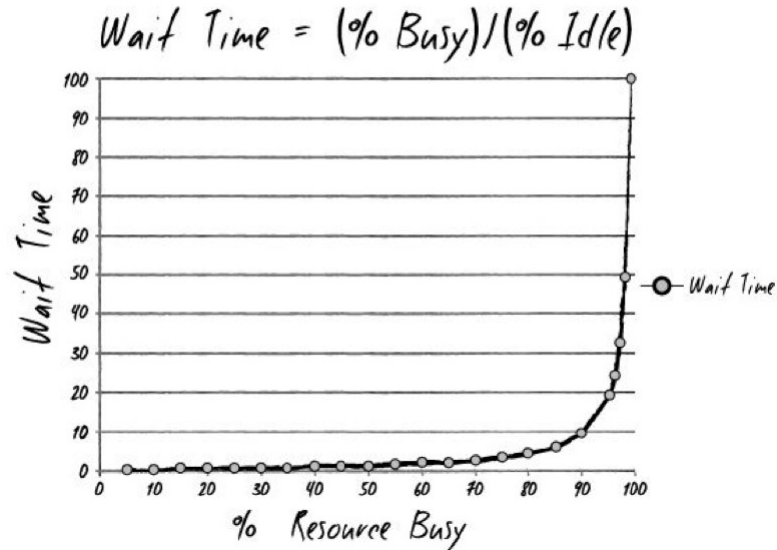
- How does Tesla eliminate bottlenecks?
  1. **Integration bottleneck:** Good test automation and simulation environment
  2. **On-boarding bottleneck:** Good documentation, fully-integrated dev system, e.g. with dynamic stages
  3. **Decision bottleneck:** Managers have to decide within one hour if they are requested by a team (if not, they are fired)

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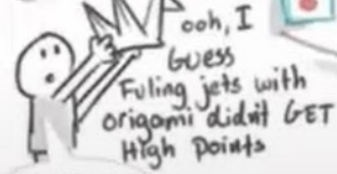
Every car is homologated on its own

- 60 parts per day are changed
- Reduxing complexity as much as possible
- Every car is certificied and homologated individually

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Digital Self_management App

Manager as a App

Then Bezos showed that teams of 6 or less don't need to elect a leader. They can simply innovate as a swarm. Amazon has 3,000 agile teams approximately this size to maximize innovation. In aggregate they release something new to the customer once per second.

そしてベゾスは、6人以下のチームにはリーダーを選ぶ必要がないことを示した。群れでイノベーションを起こせばいいのだ。Amazonは、イノベーションを最大化するために、およそこのサイズのアジャイルチームを3,000個持っている。合計すると、1秒に1回、顧客に新しいものをリリースしている。

The team board

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Value Formulas of Tesla's Autopilot

1. Can the car drive 10 meters autonomously in the factory and drive safely?

2. Can the car drive itself through the car wash?

3. Can the cars drive themselves on the transport trucks?

4. Can the cars put themselves through homologation and automated testing?

5. ...

6. Now? %SaferThanHuman / Capx+Opx -> accidents with AT on / kilometers driven

,(Latest update always goes to customer leaving nearest in order to minimize recall cost)

| VALUE	LEADING KPIs	PRODUCT
%SaferThanHuman/ 入力テストより何%安全か CAPX+OPX		**Autopilot** 自動運転
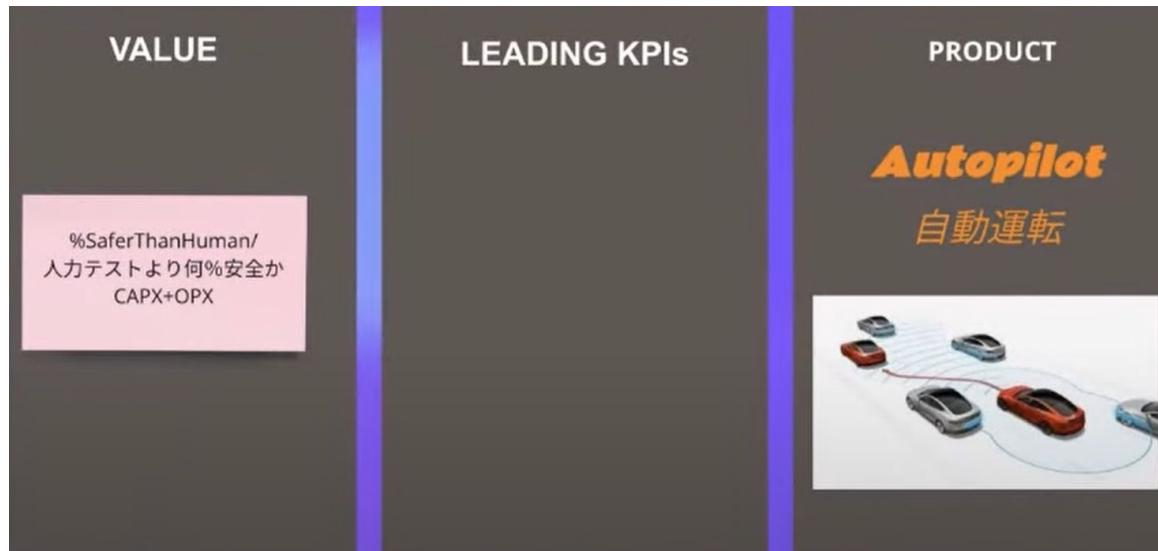
% SAFER THAN HUMAN
％人力より安全

3,200 % less likelihood of making an accident during engagement of autopilot
Increase this percentage and increase square kms on earth, which have this level

APIs are everywhere

Hardware API: Object Oriented Architecture — TESLA Model S Plaid Battery Cooling System

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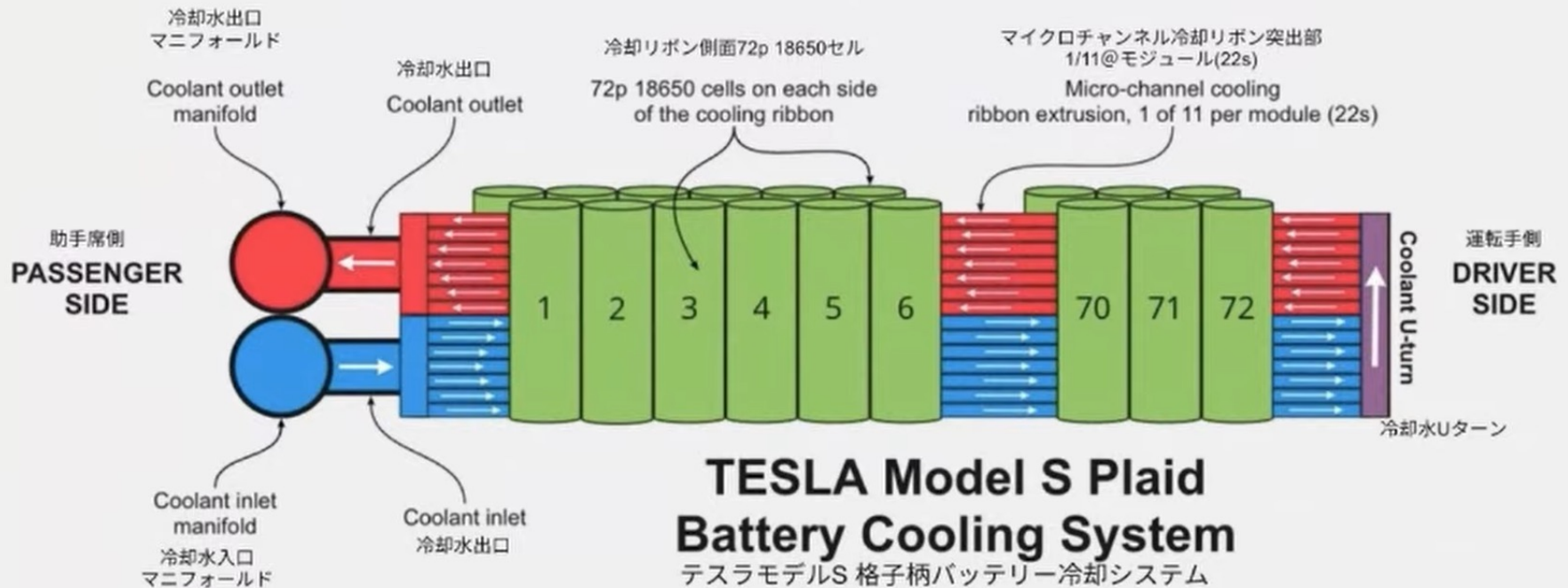
If you're looking for a traditional employee handbook filled with policies and rules, you won't find one. Policies and rules tell you where the bottom is — they tell you how poorly you can perform before you get shown the door. That's not us.

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No long meetings

Excessive meetings are the blight of big companies and almost always get worse over time. Please get out of all large meetings, unless you're certain they are providing value to the whole audience, in which case keep them very short.

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Don't have unnecessary frequent meetings

Also get rid of frequent meetings, unless you are dealing with an extremely urgent matter. Meeting frequency should drop rapidly once the urgent matter is resolved.

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Leave a meeting if you're not contributing

Walk out of a meeting or drop off a call as soon as it is obvious you aren't adding value. It is not rude to leave, it is rude to make someone stay and waste their time.

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Don't use jargon

Don't use acronyms or nonsense words for objects, software or processes at Tesla. In general, anything that requires an explanation inhibits communication. We don't want people to have to memorize a glossary just to function at Tesla

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Communicate with all departments directly

Communication should travel via the shortest path necessary to get the job done, not through the 'chain of command'. Any manager who attempts to enforce chain of command communication will soon find themselves working elsewhere.

A major source of issues is poor communication between depts. The way to solve this is allow free flow of information between all levels.

If, in order to get something done between depts, an individual contributor has to talk to their manager, who talks to a director, who talks to a VP, who talks to another VP, who talks to a director, who talks to a manager, who talks to someone doing the actual work, then super dumb things will happen.

It must be OK for people to talk directly and just make the right thing happen.

Don't follow pointless rules, use common sense

In general, always pick common sense as your guide. If following a 'company rule' is obviously ridiculous in a particular situation, such that it would make for a great Dilbert cartoon, then the rule should change.

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Tesla's Fleet

Tesla's Production Secret

Tesla's Mindset

Summary

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Summary

1. Tesla's fleet delivers high volume of data with a high variety and can be configured remotely; this paves the way of the ever-increasing accuracy of their autopilot feature

2. Tesla's production is master-branch based like modern software-development; every car is homologated on its own

3. Tesla's mindset paves the way for a high release rate

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