

MAX PLATFORM FOR AUTONOMOUS BEHAVIORS

DAVE HOFERT : PRI



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JULY 11, 2018

AV: CONTROL/DATA WORLDS COLLIDING

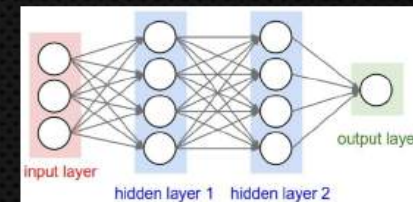
AUTOMOTIVE CONTROLS



**LOW-LEVEL
SIMPLE BY DESIGN
NARROW SCOPE FOR CONTROL**

**FULL
AUTONOMY**

ARTIFICIAL INTELLIGENCE



**ABSTRACT/PROBABILISTIC-LEVEL
HIGHEST COMPLEXITY AND VALUE
VERY DIFFICULT TO VERIFY AND
PROVE RELIABILITY**

LARGE SCALEABLE IT SOFTWARE



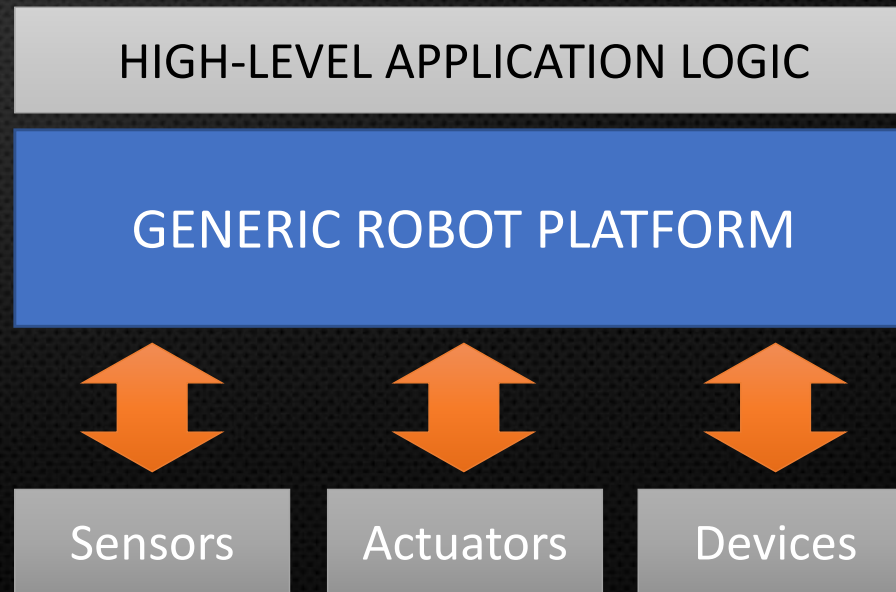
**HIGHER-LEVEL
SCALABLE COMPLEXITY FOR ADVANCED DATA PROCESSING
RELIABILITY VIA PARALLELISM, DIVERSITY**

PRI VISION: SIMPLIFY AV, ROBOTICS

FOCUS TIME SPENT ON REUSABLE SOLUTION LOGIC/UI

MAX =

*MOBILE
AUTONOMOUS
X = ANYTHING*



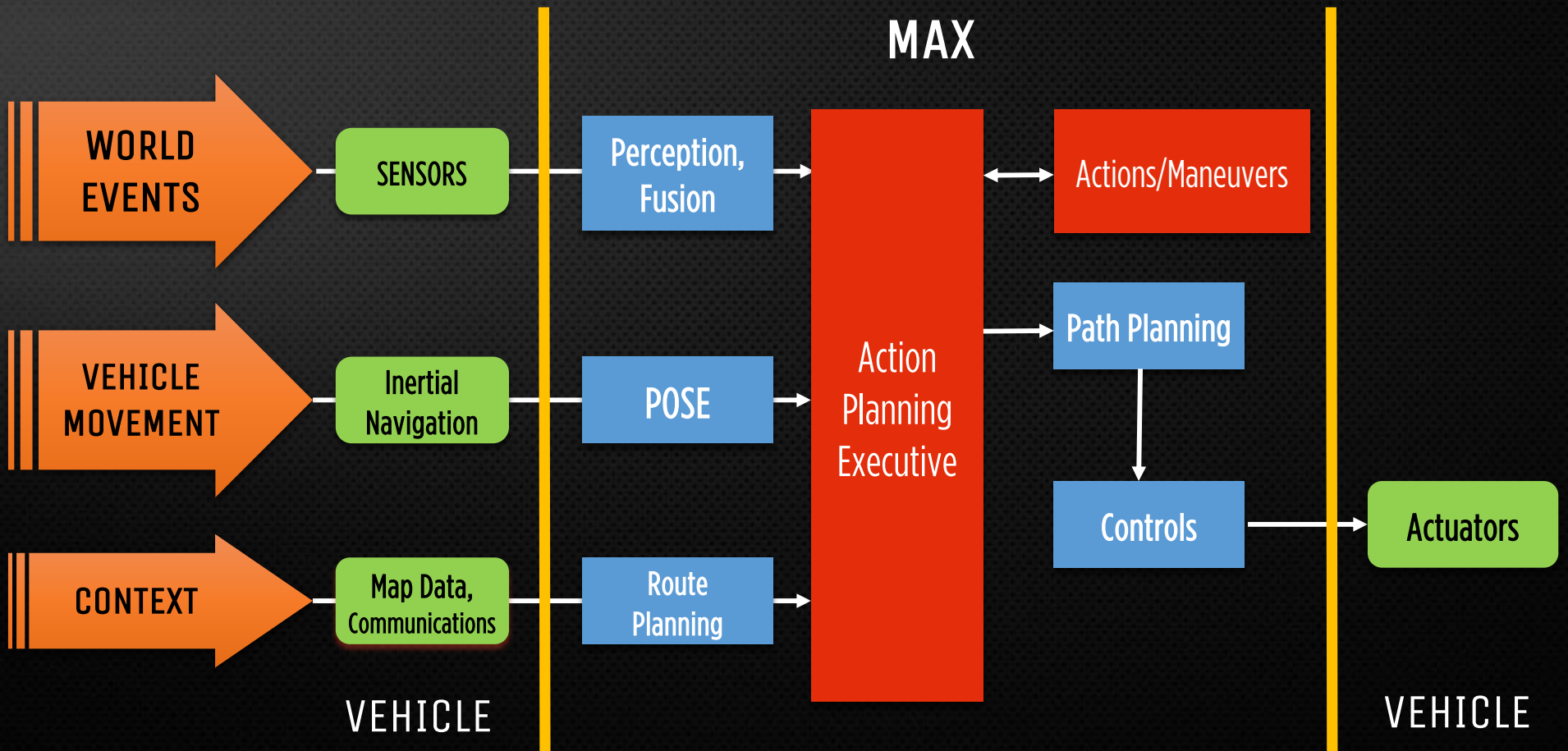
PORTABLE

SERVICES

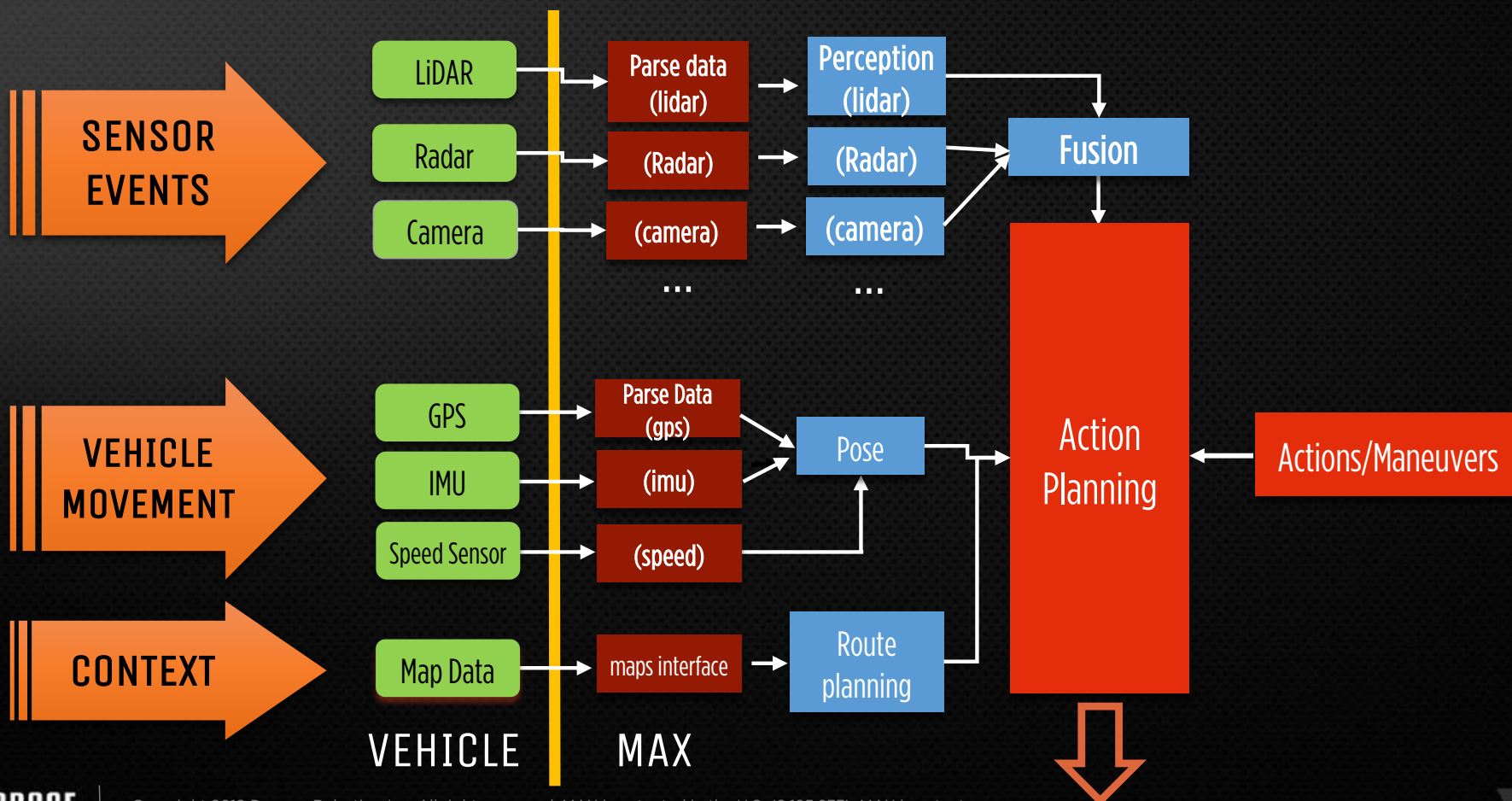
PLUG & PLAY

ANYTHING

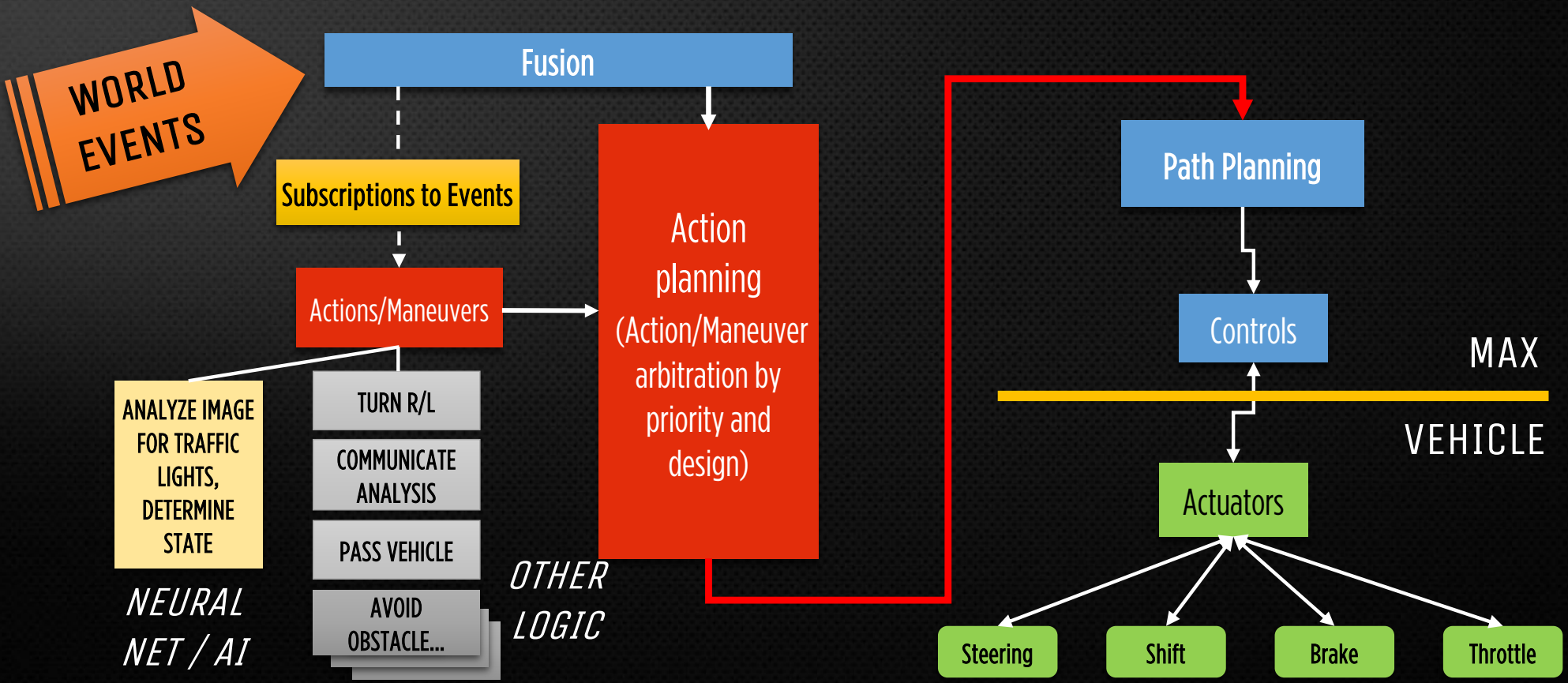
TRULY COMPLETE STACK – DEV & RUNTIME



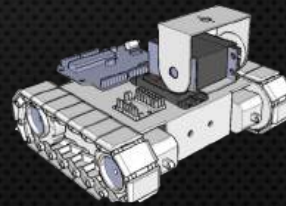
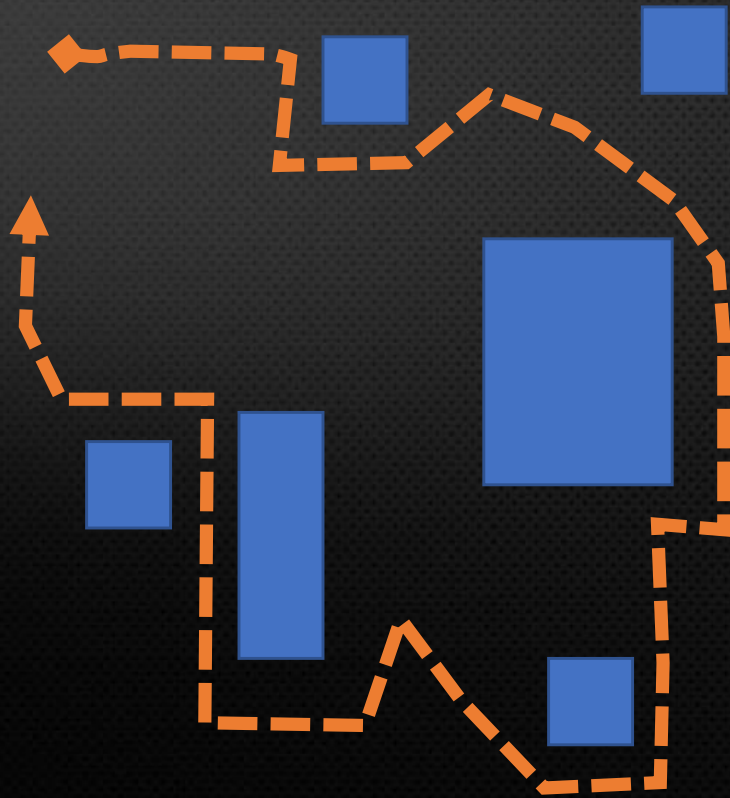
PERCEPTION AND CONTEXT SERVICES



FLEXIBLE, EXTENSIBLE MANEUVER MODEL



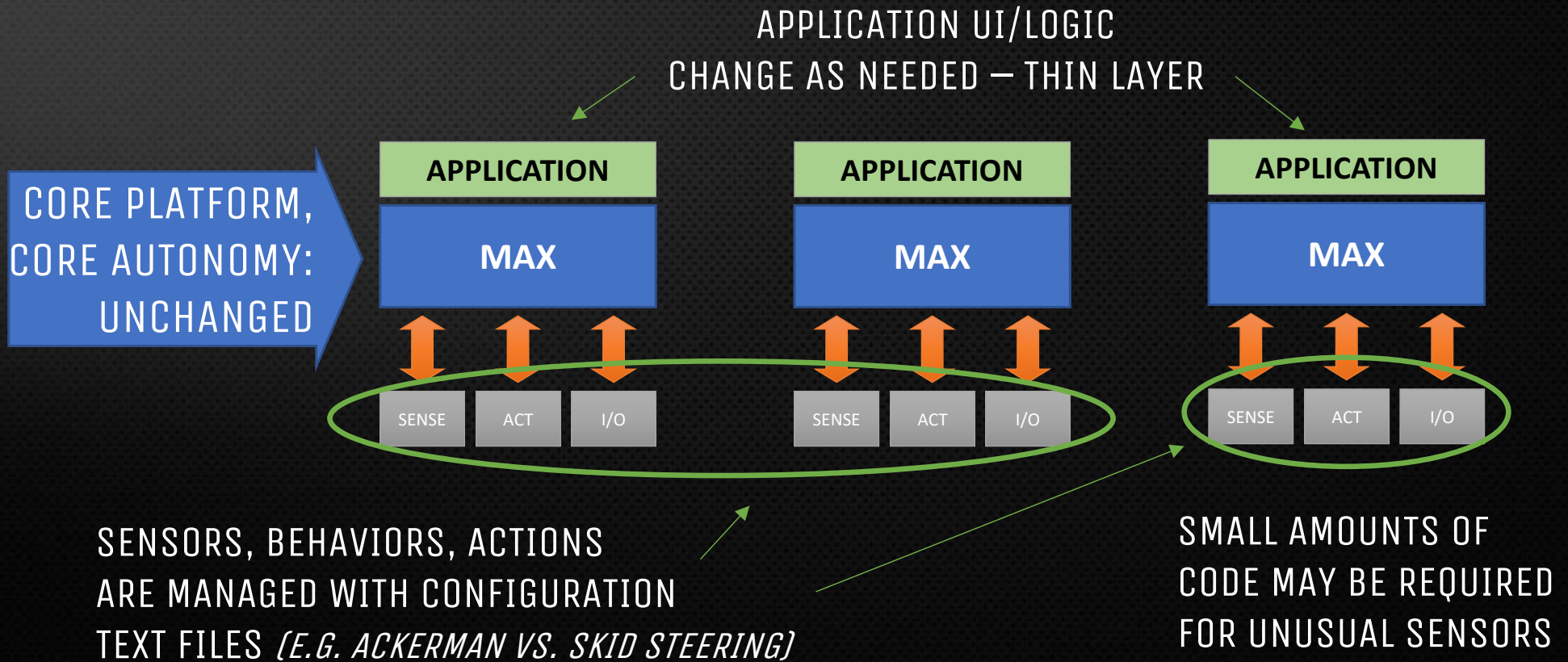
HIGHLY CONFIGURABLE



TASK: MONITOR CAMPUS WITH SEVERAL BUILDINGS

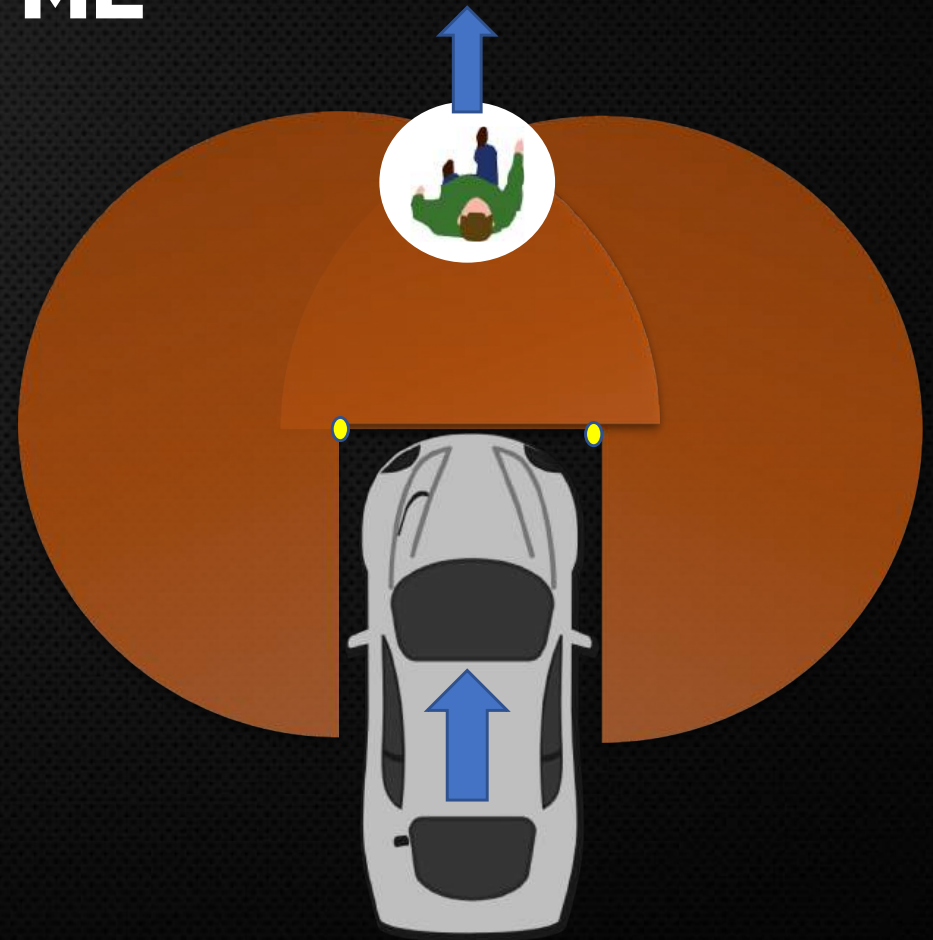
- VEHICLE 1: **STANDARD TRUCK**
 - ACKERMAN STEERING
 - FULL SIZE, COMMS, SENSORS
- VEHICLE 2: **SECURITY BOT**
 - SKID STEERING
 - TRACK-DRIVEN, FEWER SENSORS, COMMS
- BOTH CAN RUN EXACT SAME MISSION:
 - JUST CHANGE CONFIG
 - NO CODE CHANGES

WHAT CHANGES BETWEEN PLATFORMS?



SIMPLE CASE: “FOLLOW ME”

- SENSORS NORMALLY DETECT AND AVOID PEOPLE, THINGS
- IN THIS MODE, VEHICLE STILL DETECTS PEOPLE, BUT SEEKS TO KEEP PERSON IN FRONT OF VEHICLE
- SO AS PERSON MOVES, VEHICLE “FOLLOWS”
- TAKE FROM VEHICLE TO VEHICLE USING DIFFERENT SENSORS – WITHOUT CHANGES!



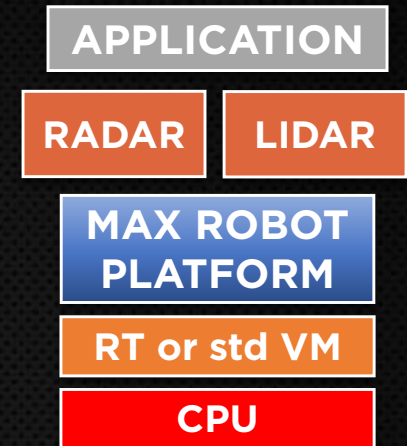
MAX REUSE ACROSS PLATFORMS/SOLUTIONS



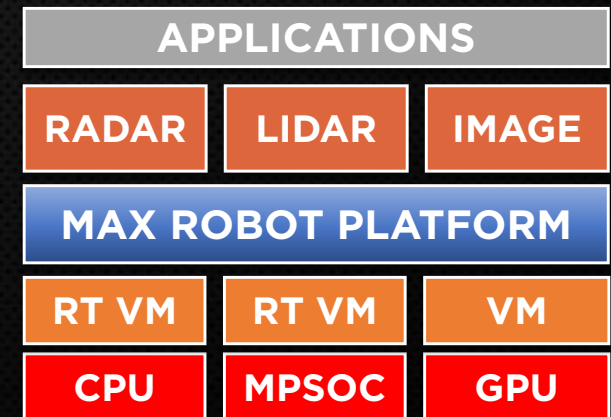
Function	AUTOMOTIVE	INDUSTRIAL	COMMERCIAL
Obstacle detection and avoidance	Developed here	Reuse without change, add negative ODA if needed	Reuse without change
V2X Communication	Reuse/Adapt, but use DSRC	Developed here – DDS	Reuse/Adapt, but use wifi
Parking Maneuver	Developed here	Reuse for loading (dump truck); add dynamic siting	Reuse for charging station
Intersection handling	Developed here	Reuse without change	Reuse without change
Dynamic course/mission changes	Add to existing re-routing	Developed here	Reuse without change
Indoors navigation	Reuse without change	Reuse without change	Developed here

FLEXIBLE ARCHITECTURE

- SCALE UP/DOWN AS TASK REQUIRES
- LEVERAGE REAL-TIME VM FOR HW/OS FLEXIBILITY
- SPECIALIZED ALGORITHMS RUN ON TUNED HW ARCH
- DISTRIBUTED PROCESSING MORE FAULT-TOLERANT
- KEY:
 - Strong HW and SW **PLATFORM** approach – IT like
 - Abstraction of HW/OS enables maximum code reuse



OR



WE HAVE DONE IT BEFORE

FIRST FULLY AUTONOMOUS VEHICLES
(HISTORIC DARPA GRAND CHALLENGES)



INTEL CAPITAL INVESTMENT
GROWTH & TEST TRACK FACILITY



STRATEGIC
CUSTOMERS

Premium Brand
Automotive OEM

Tier 1 Auto
Supplier

LIEBHERR

Multinational PC
Manufacturer

WIND
AN INTEL COMPANY

2017-2018

2004-2007

COMMERCIAL & SHOWCASE
DEPLOYMENTS

(PA TURNPIKE, AUTONOMY KITS, NEIL
YOUNG, HARVESTER, ETC.)



2008-2015

2016-2017

FIRST ROBOT



2003



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LOCATED IN CROZET, VIRGINIA



PRIVATE TEST TRACK



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SOLUTIONS IN MANY AREAS



MAXIMUM VALUE

- **A TRULY FLEXIBLE PLATFORM, PROVEN OVER MANY IMPLEMENTATIONS**
 - Unique combination of configurability, hardware/communications flexibility
 - Algorithm modularity, Full stack/suite of app services
- **MIGRATE SEAMLESSLY ACROSS PROJECTS TODAY**
 - Leverage inherent network effect from MAX platform model
- **IP: PLATFORM PATENTED IN 2006**
 - With extension (continuance in part) this Spring
- **PATH TO PRODUCTION/CERTIFICATION**
 - MAX built with production in mind – not just R&D, but actual deployment
 - Beginning work on 61508 certification (SIL 2 to start)

THANK YOU!
QUESTIONS?

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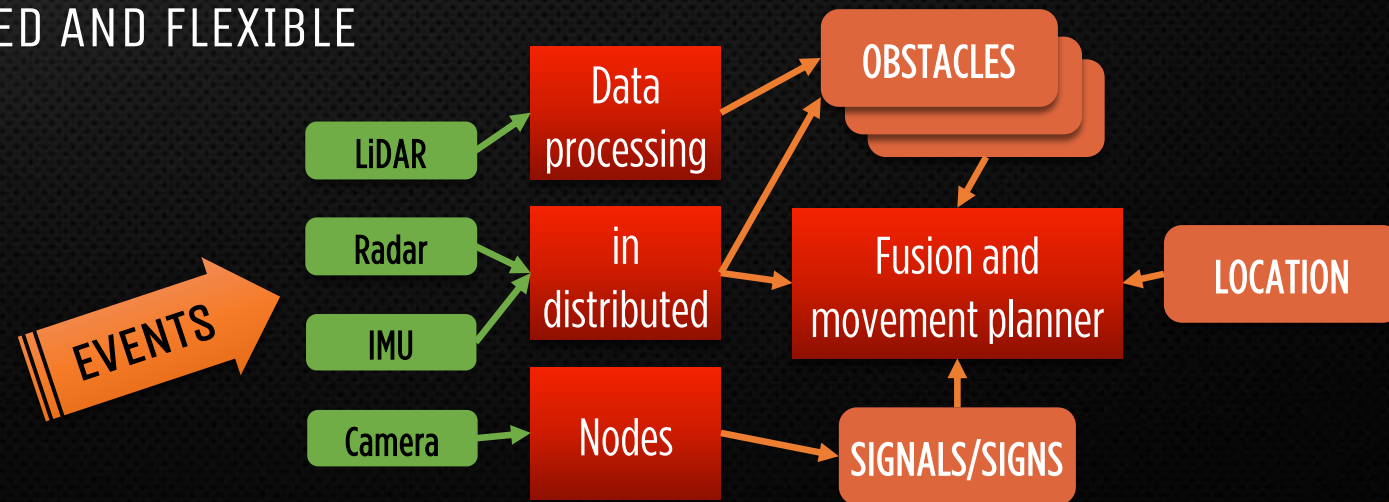
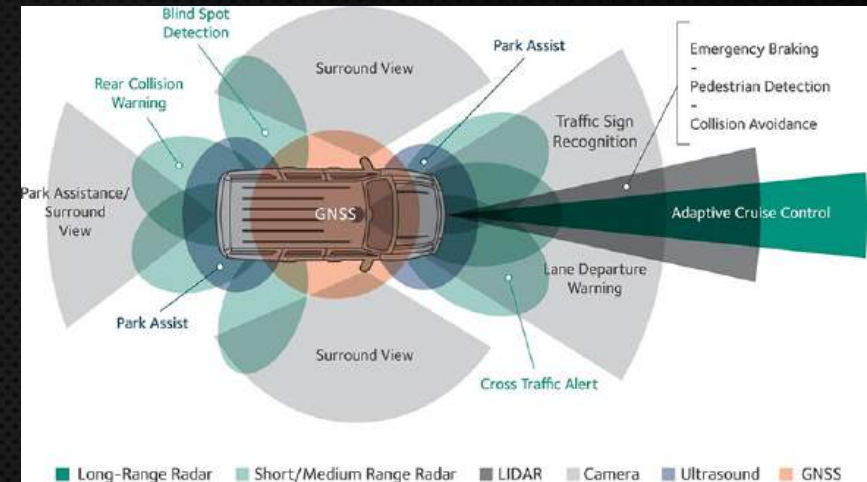
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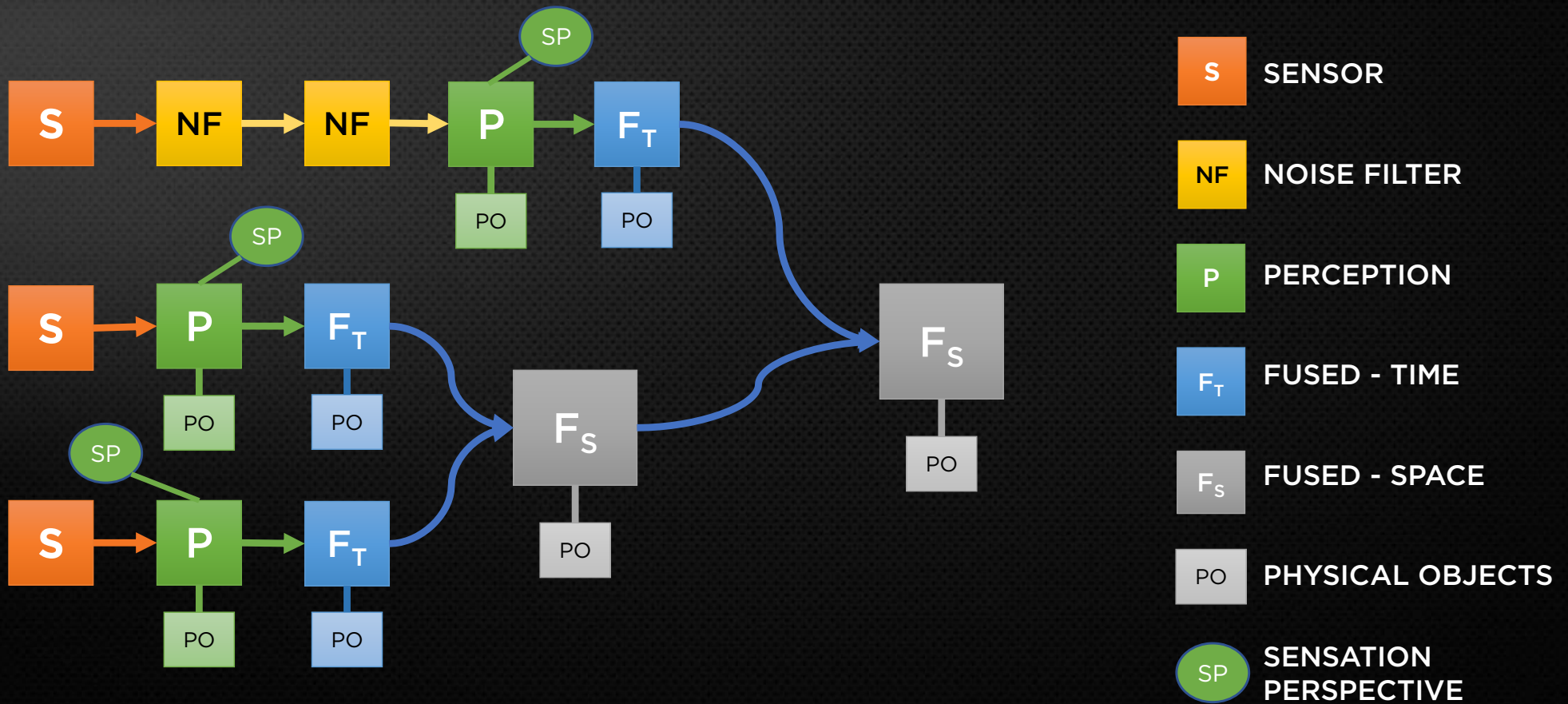
FLEXIBLE AUTONOMY

DISTRIBUTE PROCESSING, LAYER ON AI, ACCELERATION AS NEEDED

- GPS IS PRIMARY LOCALIZATION
- **ADD** LANE-KEEPING WHEN GPS IS POOR
- **ADD** SENSOR DATA TO MANAGE OBSTACLES
- **USE** SMALLER, DISTRIBUTED AND FLEXIBLE PROCESSORS
 - LOW POWER, LOW HEAT
- **USE** MORE WHEN NEEDED



FUSION IN TIME AND SPACE



MULTI-SENSOR FUSION APPROACH



SENSOR DIVERSITY FOR SAFETY, RELIABILITY IN AUTOMOTIVE

- GPS FOR CORE LOCALIZATION
- CAMERA FOR ADVANCED DETECTION, LOCALIZATION (AI-BASED)
- 16-BEAM LIDARS
 - USE 1-4+ AS NEEDED FOR OBSTACLE IDENTIFICATION
- RADARS FOR LONG-RANGE OBSTACLE DETECTION

MULTI-SENSOR FUSION APPROACH - II



HAUL TRUCK: VERY SIMILAR TO AUTOMOBILE - SAME PLATFORM, JUST RECONFIG

- GPS FOR CORE LOCALIZATION
- CAMERA FOR ADVANCED DETECTION (AI-BASED)
- RADARS FOR LONG-RANGE OBSTACLE DETECTION
- 8-BEAM LIDARS FOR SMALLER OBSTACLE DETECTION