

WHERE GNSS WENT NEXT

Alan Cameron, *GPS World*

OUR WORLD HAS CHANGED

You ain't seen
nothing yet.



In 10 or 20 years, racetracks may be the only place where you're allowed to drive your own vehicle.

LYFT AND UBER ARE THE FACEBOOK AND GOOGLE OF THE FUTURE

Trucking fleets also serve a critical role in pushing autonomous technology forward.



THE AUTONOMOUSLY NAVIGATED FUTURE.

We are caught in the act of seeing
ourselves become obsolete.

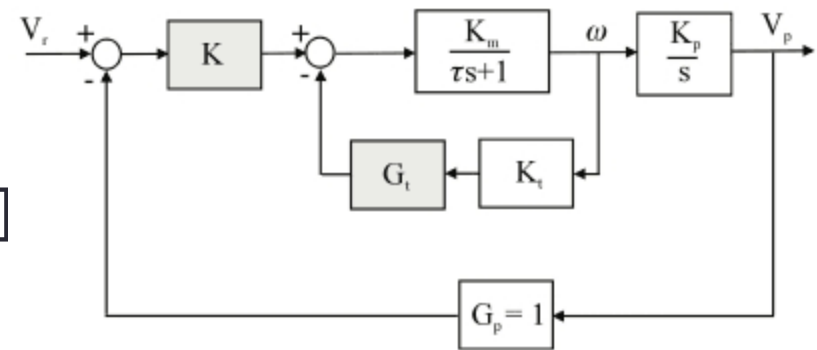
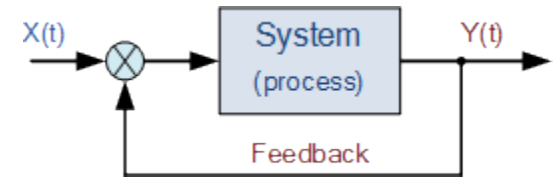
**THE HUMAN IN THE LOOP (HIL)
IS THE BIGGEST SOURCE OF
ERROR AND CATASTROPHE.**



Time Sensitivity for Automotive Networks

Let's do the numbers [Order of Magnitude]

- 60 mph => 100 km/hr
30 m/s => 3 **cm/millisecond**
- System level response => **msec**
=> **1KHz update rates** minimum
- Subsystem responses =>
10 – 100 usec range
- Network latency =>
< 100 usec over multiple hops [5-7]
 - alternate fault tolerant paths
 - all Bit Error Rate [BER] conditions



Latency is key if the network is part of the control loop:

- *Stability*
- *Dynamic performance*

What would Autonomous do?



GPS PROVIDES THE POSSIBILITY OF OMNISCIENCE.

**GPS itself is a blank slate
onto which we project our
desires.**

EUROPE LEADS THE ADVANCE TO AUTONOMOUS ROAD TRAVEL



MOBILITY AS A SERVICE

**Travel may resemble
healthcare.**

SAFETY, EFFICIENCY, REDUCED CONGESTION.

- **Zero-emissions society and circular economy**
- **Benefit to the aging population**
- **Improved mobility in rural areas**

KEY ISSUES

- security
- use of data
- liability
- public support
- co-existence of autonomous and manual cars
- social inclusion
- privacy
- ethics



THE ECOSYSTEM HASN'T
FORMED YET.
NOBODY KNOWS WHAT IT
LOOKS LIKE.

- The map is critical.
- Go deeper into representation of sensor data and environment.
- GNSS at the core of that.
- Trust is key in a vehicle controlling itself.

EVERYONE TALKS ABOUT THE WEATHER

But nobody does anything
about it.

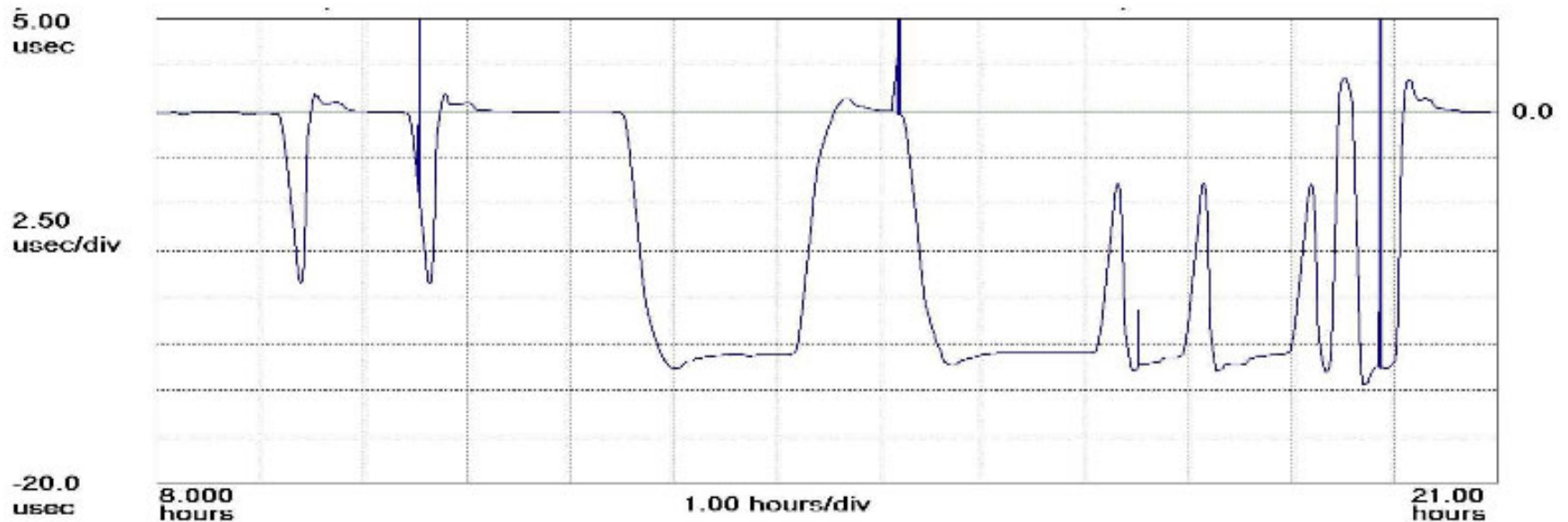
— *Right?*



Automated All-Weather Driving



WORLD DODGES GPS BULLET



Microseconds Go Missing in GPS Ground Control Glitch

Timing receivers of several companies around the world were hit by hours of system warnings after 15 GPS satellites broadcast the wrong time — off by 13 microseconds — on Jan. 26.

At 12:49 a.m. MST on that date, the 2nd Space Operations Squadron (2 SOPS) at the 50th Space Wing, Schriever Air Force Base, Colo., verified users were experiencing GPS timing issues. Further investigation revealed an issue in the GPS ground software that only affected the time on legacy L-band signals. This change occurred when the oldest vehicle, SVN 23, was removed from the constellation.

While core navigation systems were working normally, the Coordinated Universal Time timing signal was off by 13 microseconds, which exceeded

design specifications. The issue was resolved at 6:10 a.m. MST; however, global users may have experienced GPS timing issues for several hours.

U.S. Strategic Command's Commercial Integration Cell, operating out of the Joint Space Operations Center, effectively served as the portal to determine the scope of commercial user impacts. The Joint Space Operations Center at Vandenberg Air Force Base did not receive any reports of issues with GPS-aided munitions, and determined that the timing error was not attributable to any type of outside interference such as jamming or spoofing.

Operator procedures were modified to preclude a repeat of this issue until the ground system software is corrected, and the 50th Space Wing will conduct an Operational Review Board

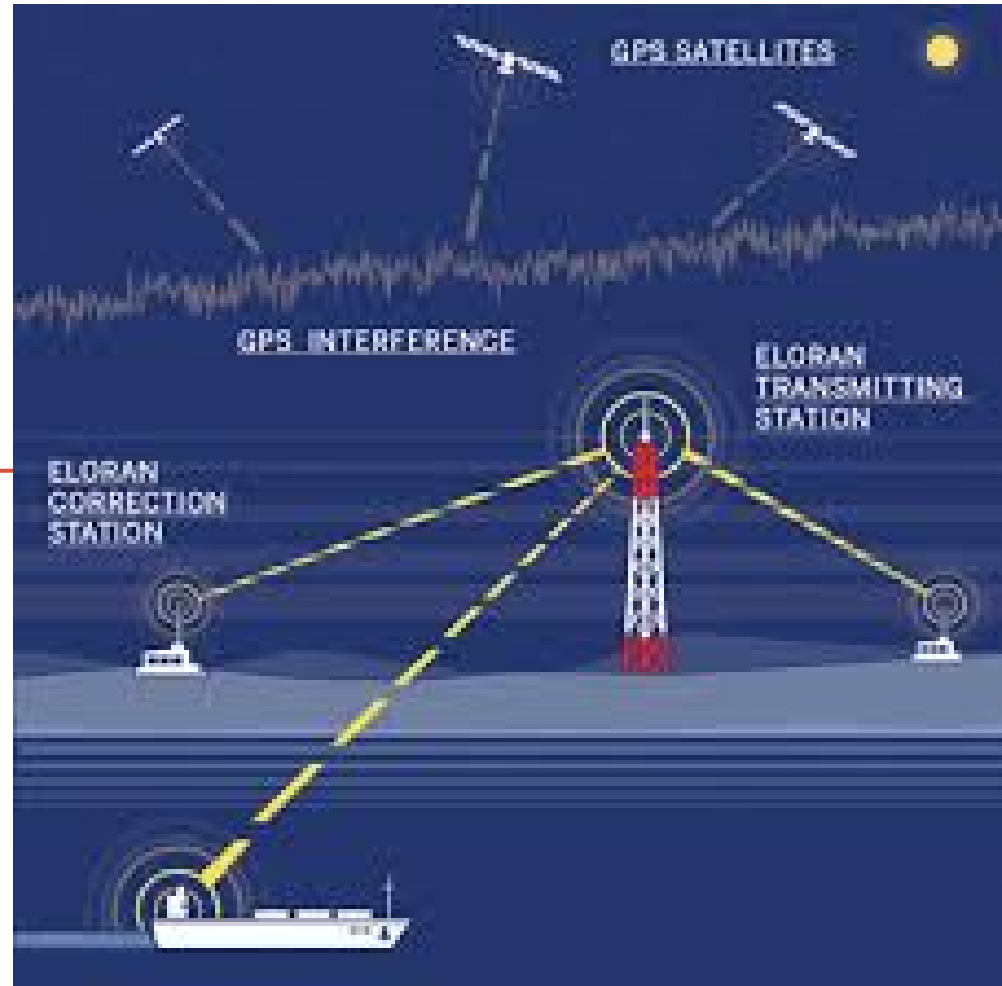
to review procedures and impacts on users. Commercial and Civil users who experienced impacts can contact the U.S. Coast Guard Navigation Center at (703) 313-5900.

A week after the incident, Chronos Technology reported that problems for its clients, nearly 100 timing equipment users in more than 50 countries around the world, continued for two days after the anomaly first appeared.

Telecommunications, financial and utility companies, among others, rely on the highly precise accuracy of time measurements to control the flow of data through their networks. When the 13 microsecond error was detected, it produced thousands of system warnings at some companies.

The problem did not affect other GPS users in navigation, survey, transportation or other sectors. 🌐

BLIND RELIANCE ON A SINGLE STRING OF VULNERABLE TECHNOLOGY?



THE NIGHT GPS FAILED

R

Film Preview



Mr. Suburban



Mrs. Suburban



Mr. Suburban



Mrs. Suburban



Mr. Suburban



Power grid control engineer



U.S. President



Air Force Chief Scientist



U.S. Armed Forces Chief of Staff



U.S. President



U.S. Armed Forces Chief of Staff



U.S. President



U.S. Armed Forces Chief of Staff



Based on a true story

Atlantic magazine,

“What Happens If GPS Fails”

by Dan Glass

June 2016

RESILIENCE

Big Data

Location, Location, Location? (3) Integrate, Integrate, Integrate! Interoperability and Crosswalking



Integrate With Your Other Systems and Data Assets

INTEGRATE,
INTEGRATE,
INTEGRATE!

More data,
and more disparate data,
than ever before.

RESILIENT PNT WILL MEAN MORE THAN COMPLEMENTARY SENSORS

A seamless mesh of hardware and software, much of it from sources we don't currently consider PNT-relevant, of input from amateur app makers and crowd-sourced data from users, and more.



Wanted: 800-lb. gorillas
— 363 kilos?

GOOGLE AND APPLE

Intel and Microsoft

Satellite Navigation & Positioning Laboratory


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Google to Provide Raw GNSS Measurements

10 July 2016

Raw GNSS measurements from Android phones. Yep, they are coming. At Google we have been working with our GNSS partners to give application developers access to raw GNSS measurements from a phone.

This is really exciting, and marks a new era for our GNSS community. At Google I/O in May, we announced that raw GNSS measurements are available to apps in the Android N operating system, which will be released later this year. This means you can get pseudoranges, Dopplers and carrier phase from a phone or tablet.

When can you get it? Well, it will take some time to proliferate throughout the ecosystem, but the first phone that will provide raw measurements will be the Nexus phone that we will launch later this year, and then next year you will see new Android handsets start to support it, as it will become a mandatory feature in Android.

Read more in *GPS World* article. <http://gpsworld.com/google-to-provide-raw-gnss-measurements/>

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NAVIGATION AS A STATE OF MIND

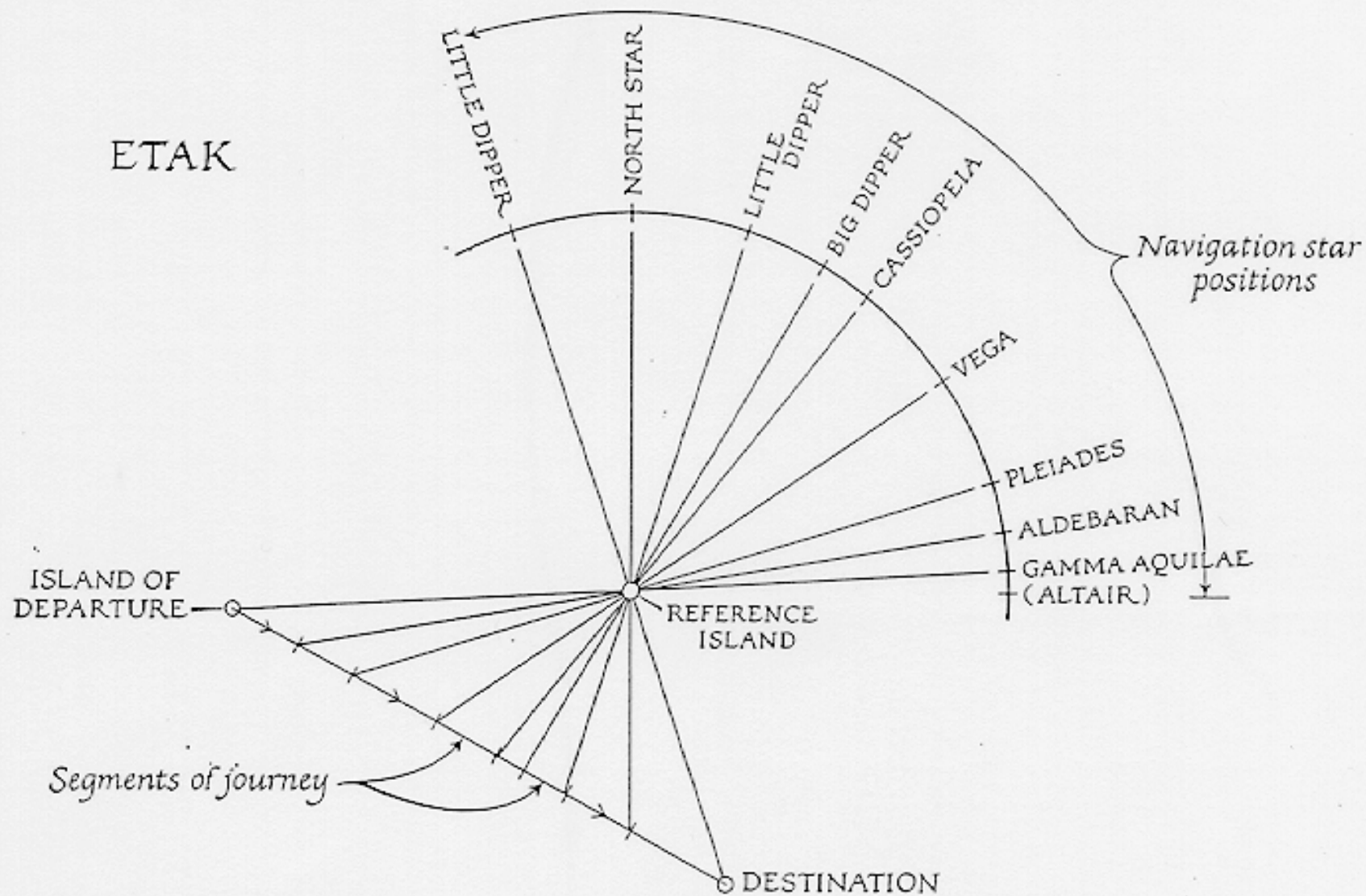


PINPOINT

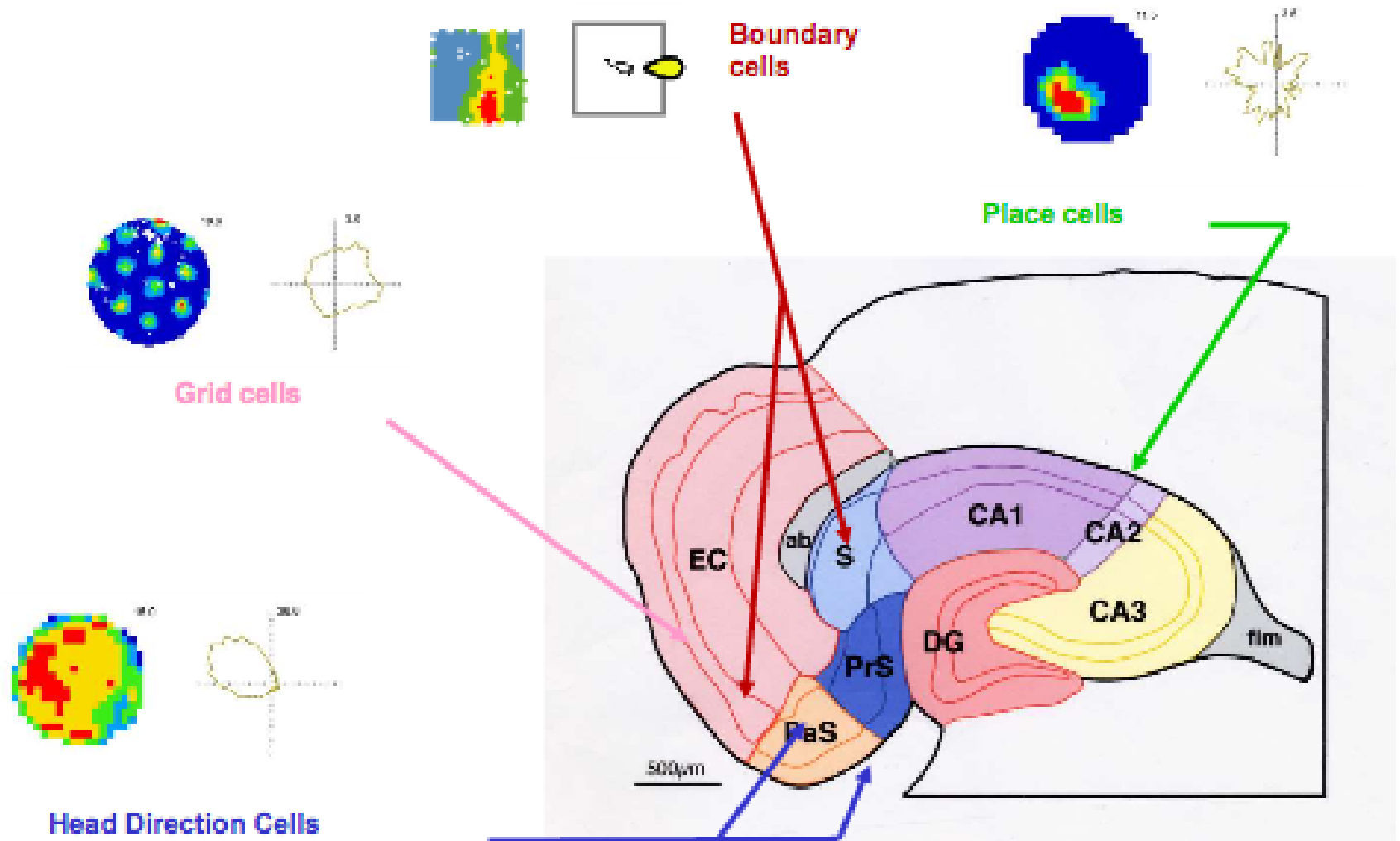
HOW GPS IS CHANGING TECHNOLOGY,
CULTURE, AND OUR MINDS

GREG MILNER

ETAK



Spatial cells in the hippocampal formation



Mari Sandoz

CHEYENNE AUTUMN



