

*33rd Annual Convention & Technical Symposium
International Loran Association*

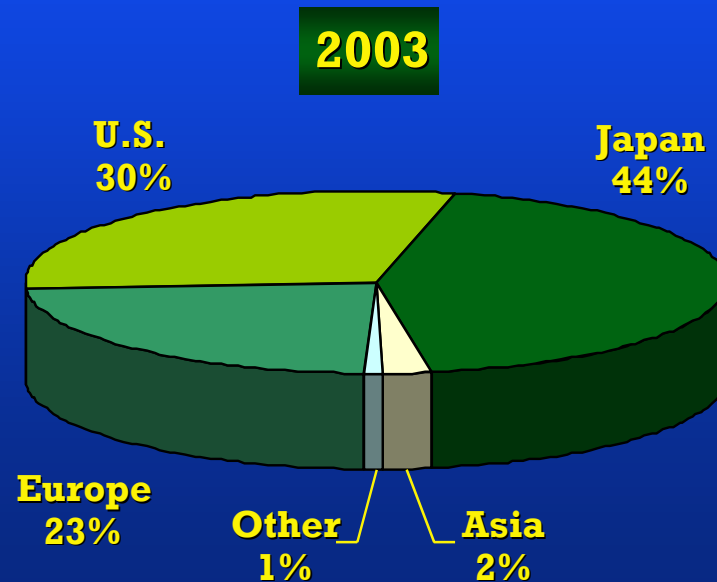
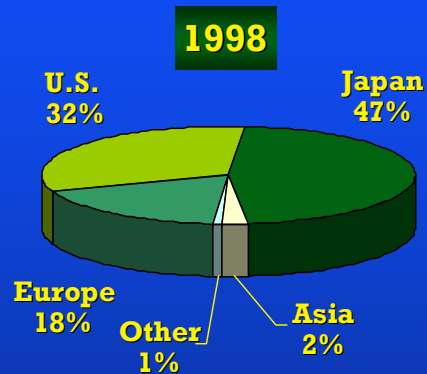
A picture of the future of radionavigation

Professor David Last
University of Wales



*25 October, 2004
Tokyo, Japan*

GPS Sales by Geographic Region



Source: DOC, 1998

Picture: J.Y. Kim, US Dept of Commerce, UN/USA
Workshop on Use of GNSS, Lusaka, Zambia, Jul 2002



From: Kelvin Hughes Ltd.



The location of a person carrying this small device is displayed on a computer screen. (Jiji)

Making Wireless Roaming Fun

Change gallery: All Images Go



- #1 Matto 681 pt
- #2 chamou 327 p
- #3 Arch 192 pt
- #4 3013 78 pt
- #5 taka 54 pt



©CMJ/Alps Mapping

Tracking Your Kid with GPS

GPS:

Why use anything else?

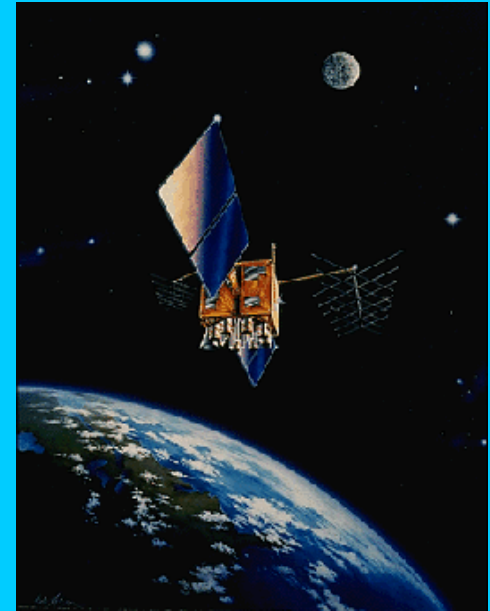
- **Ownership**
- **Share of rewards**
- **More satellites**
- **Better accuracy and integrity**
- **Less vulnerable to interference**
- **Indoor navigation**



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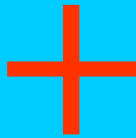
The Presidential Decision Directive



The US government will ...

“Limit availability of radionavigation systems ... in the event of a real or potential threat of war or impairment to national security.”

1999 Federal Radionavigation Plan, Section 1.5(l)

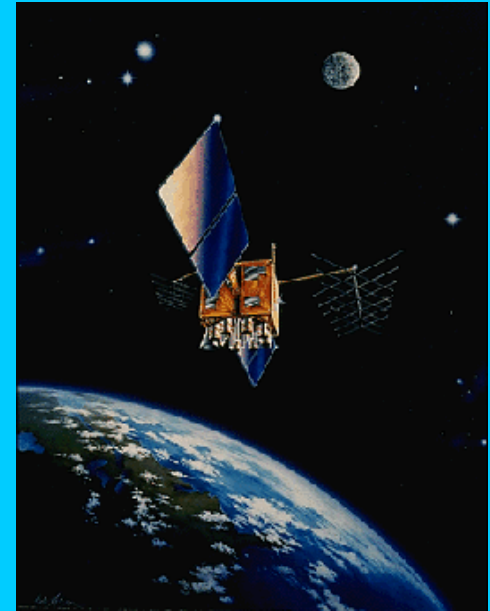


Picture: europa.eu.int/comm/dgs/energy_transport/galileo/applications/index_en.htm

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The Presidential Decision Directive



**GPS is an integral component
of the ... global information
infrastructure, with applications
... from mapping and surveying to
... air traffic management**

‘U.S. Global Positioning System Policy’, Fact sheet ,Office of Science and Technology Policy,
National Security Council 29 March 1996

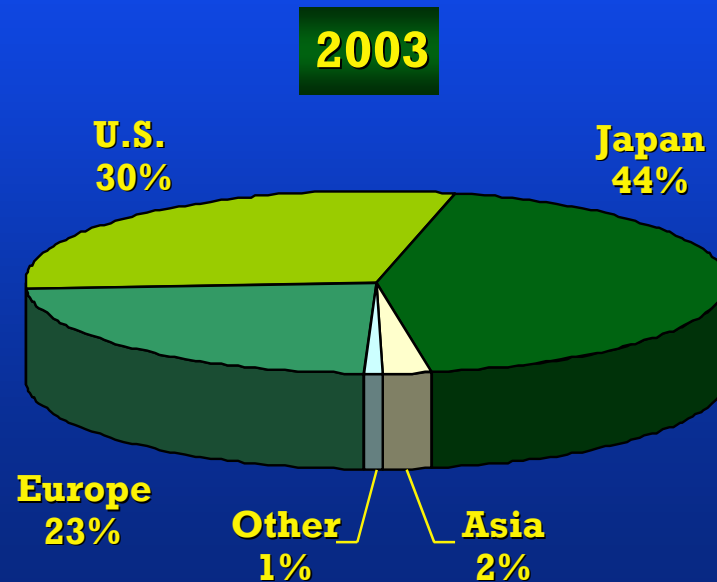
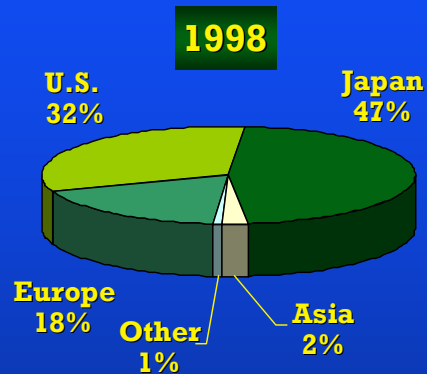
The Presidential Decision Directive



**GPS has ... generated a US
commercial equipment and service
industry that leads the world.**

White House Press Release, 29 March 1996

GPS Sales by Geographic Region



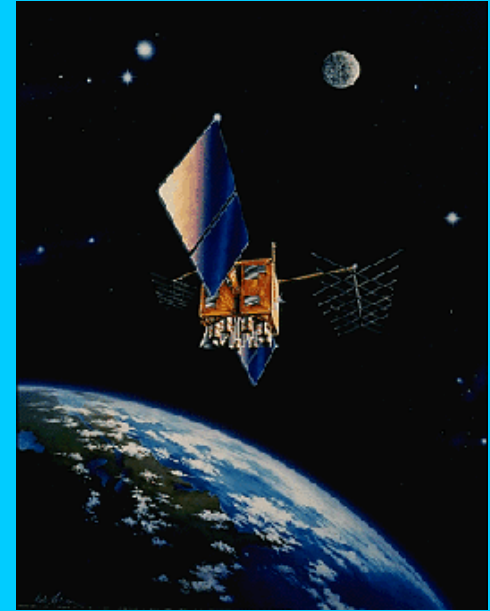
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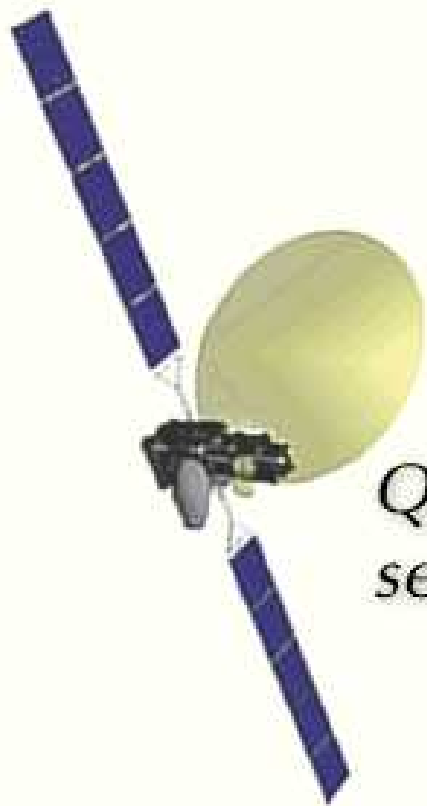
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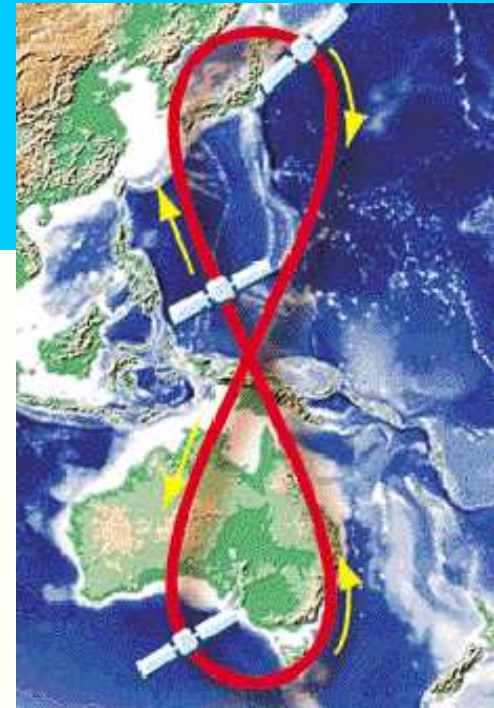
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*Quasi-Zenith Satellite System (QZSS),
seeking for the potential.*

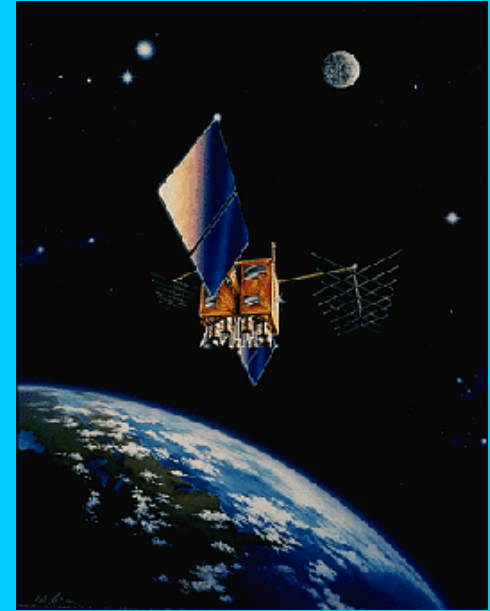


Pictures: ACJJ Journal, Dec 2003; ASBC

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WAAS, EGNOS & MSAS

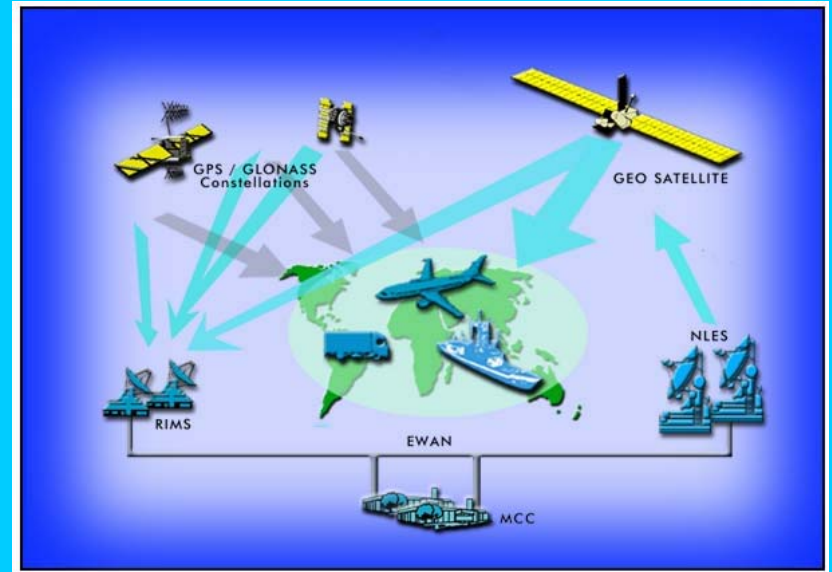


Figure: European Space Agency

- Continent-wide augmentation of GPS
- Broadcast from GEO satellites
- Extra GPS signals, safety-critical
- Aviation and multi-modal
- Enhance accuracy and integrity

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U.S. DOT/Volpe Center

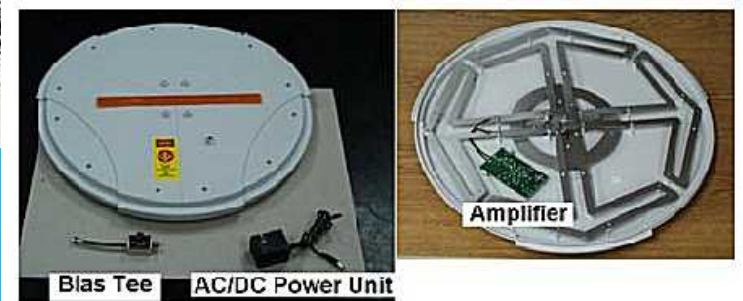
Vulnerability Assessment

of the Transportation Infrastructure
Relying on GPS

- **Threat of unintentional interference and jamming**
- **Risks can be reduced but not eliminated**
- **Consequences severe for safety, economic damage**
- **Tempting target for those hostile to the US**
- **Can be spoofed to give misleading information**
- **Need backup system in critical applications**



Dice is 1mW GPS jammer

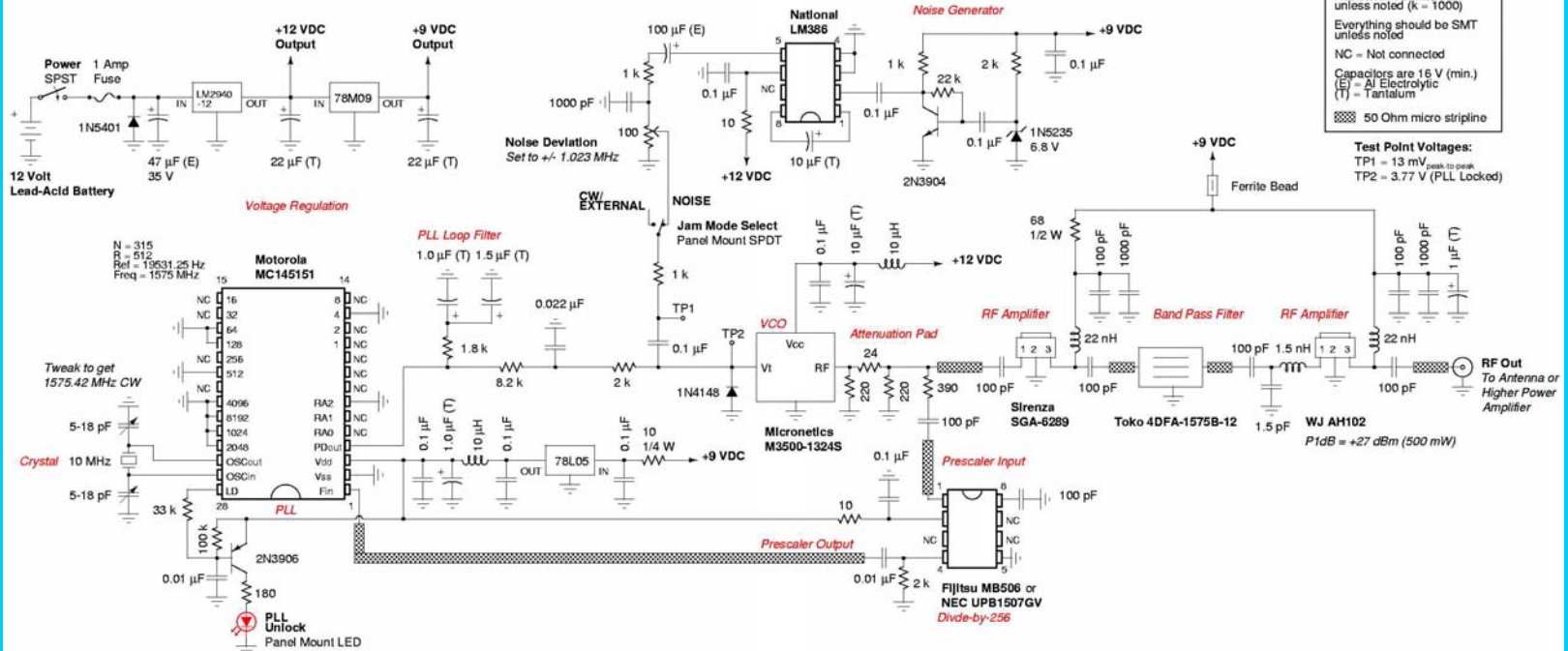


Radio Shack 15-1624 VHF/UHF Antenna

Source: Clynch *et al.*, 'Multiple GPS RFI Sources in a Small California Harbor', ION GPS02, Portland OR.

GPS Jammer

Noise Jammer for the L1 GPS Frequency (1575.42 MHz)



**Pentagon fürchtet
40-Dollar GPS-
Störsender der
ferngelenkte
Raketen blockiert.**

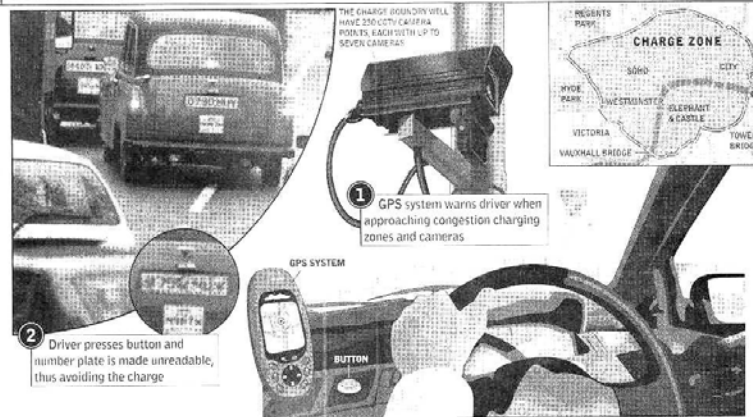


GPS for the London Congestion Zone?



19 January 2003 **The Observer**

SABOTAGING THE SYSTEM



Gadgets aim to fool cameras

Observer, London, 29 Jan 2003

- *GPS Jammer Plans*
- *Police Laser (lidar) Radar Jammer Plans*



ADD TO CART



ADD TO CART

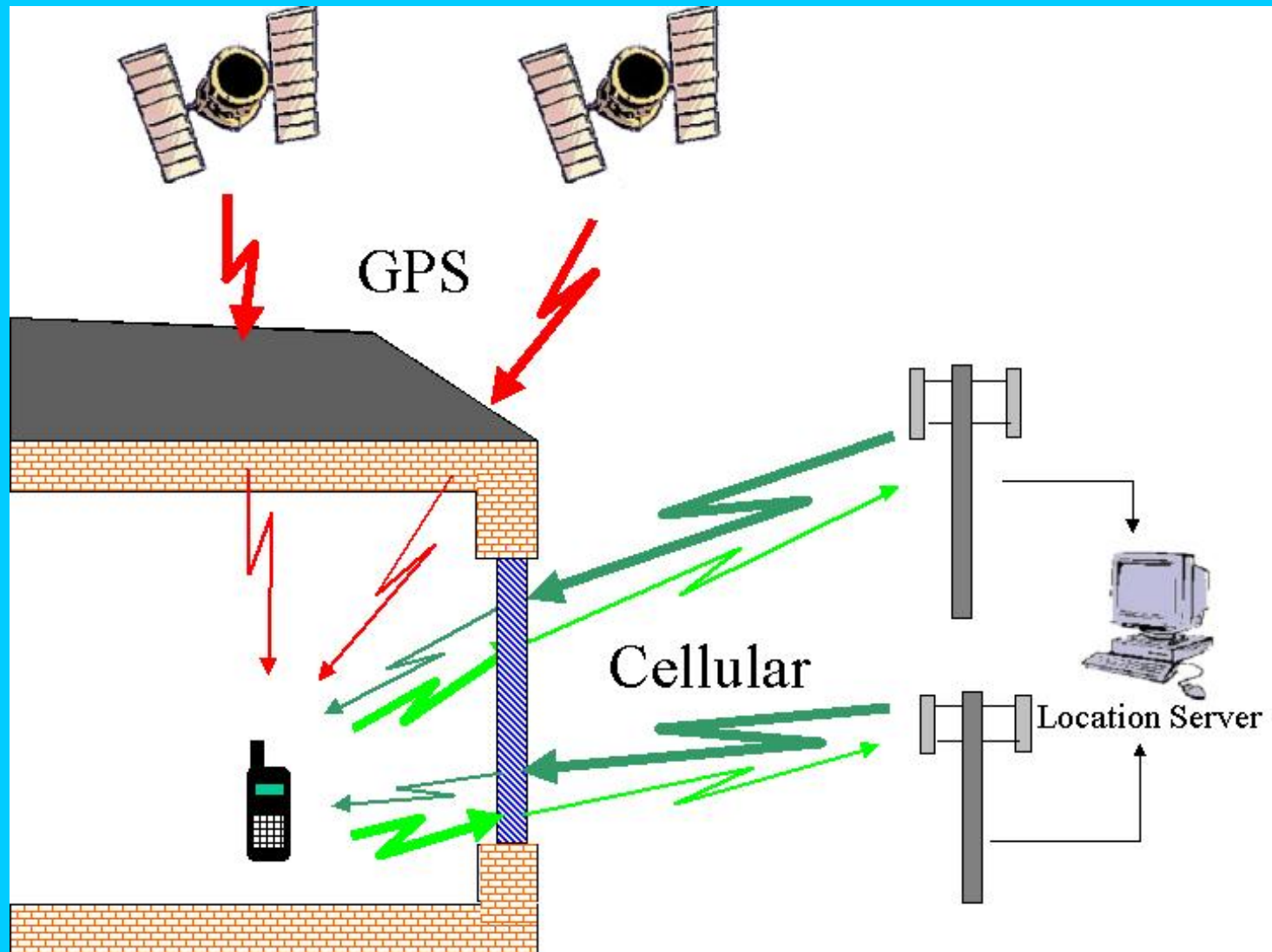
<http://www.kenneke.com/plans.html#>

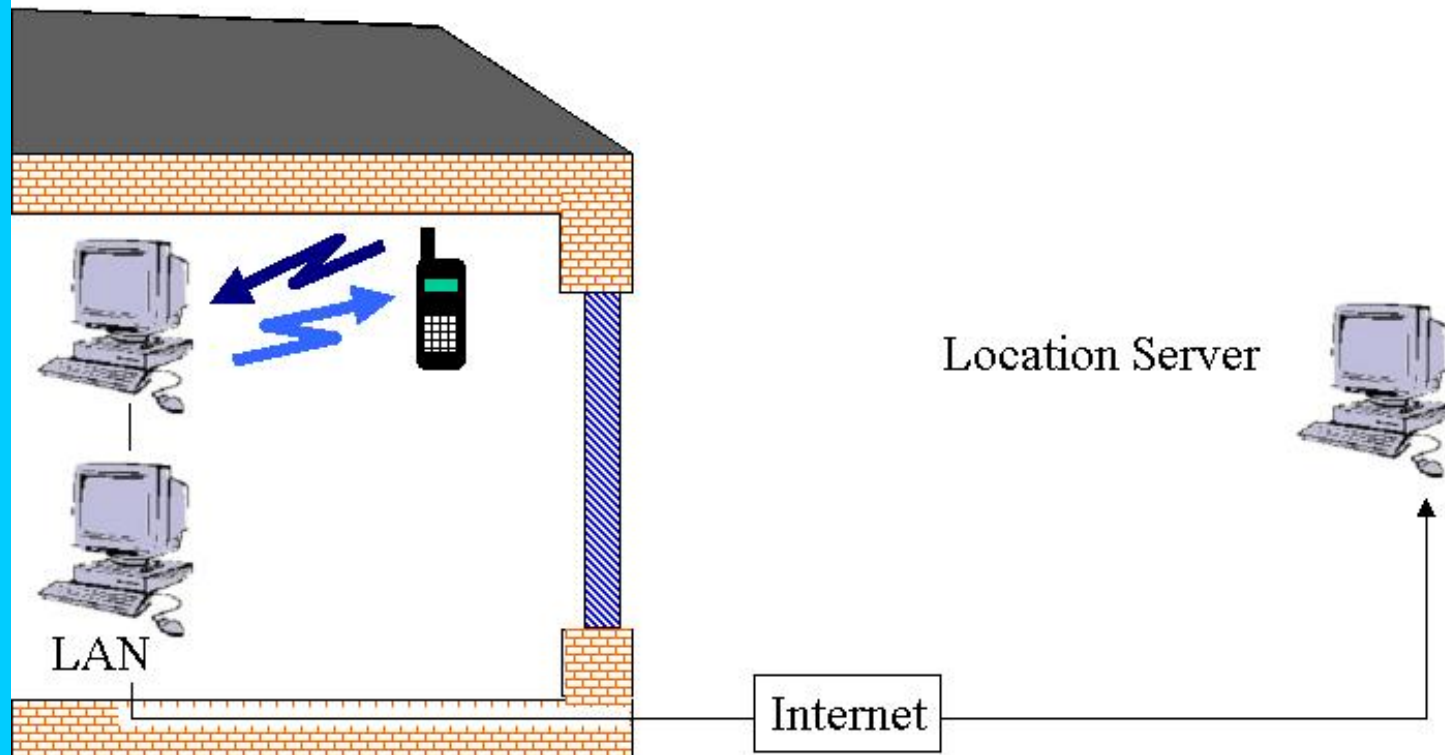
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GPS: Use anything else?



Ownership	NO. Does not give independence. Not possible for most nations.
Rewards	NO. Rewards come from manufacturing and sales, not operating satellites.
Satellites	YES. We need MORE SATELLITES. Common receivers need compatibility with GPS.
Accuracy	YES. More satellites: higher accuracy and integrity. But chiefly from AUGMENTATION.
Interference	YES. NON-SATELLITE SYSTEMS to reduce vulnerability to jamming and interference.
Indoors	YES. GPS alone won't do. What will?



Photo: Ashtech, Inc.



U.S. DOT/Volpe Center

Vulnerability Assessment

of the Transportation Infrastructure
Relying on GPS

***Volpe says
Loran-C ...***

- **Is viable for coastal operations**
- **Is very effective for land tracking**
- **Can replace GPS for telecomms timing**
- **Is a potential backup for aviation**

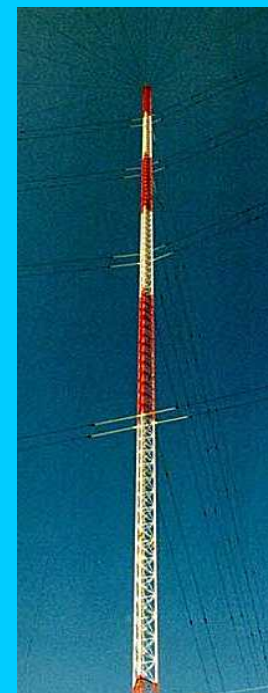
Enhanced Loran-C?

Ownership	YES. Owned by nation or region.
Rewards	YES. Free market in equipment.
Satellites	YES. More available in urban areas and forests.
Accuracy	YES. Can be comparable to satellite. Built-in integrity checking.
Interference	YES. Much less vulnerable to jamming and interference.
Indoors	OK. Can be better than GPS.



The future radionavigation mix?

- **GPS**
- **Other satellite:**
Galileo, QZSS, compatible, common receivers, free-to-air, some restricted
- **Augmentations:**
SBAS: MSAS, WAAS, EGNOS
GBAS: Radiobeacons, Eurofix
- **Aviation:** ILS, DME, NDB, VOR
- **Enhanced Loran-C:**
Combined with satellite
- **Indoor navigation system(s)**



A picture of the future of radionavigation

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