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eLoran + GNSS: Resilient & Cost-Effective PNT

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Presented at the 38th Annual ILA Convention, Portland ME, USA

Resilience

- Robustness
- Redundancy
- Resourcefulness
- Rapidity

Source: Northern Lighthouse Board

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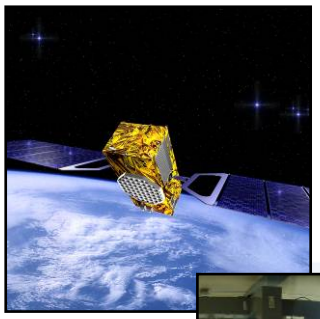
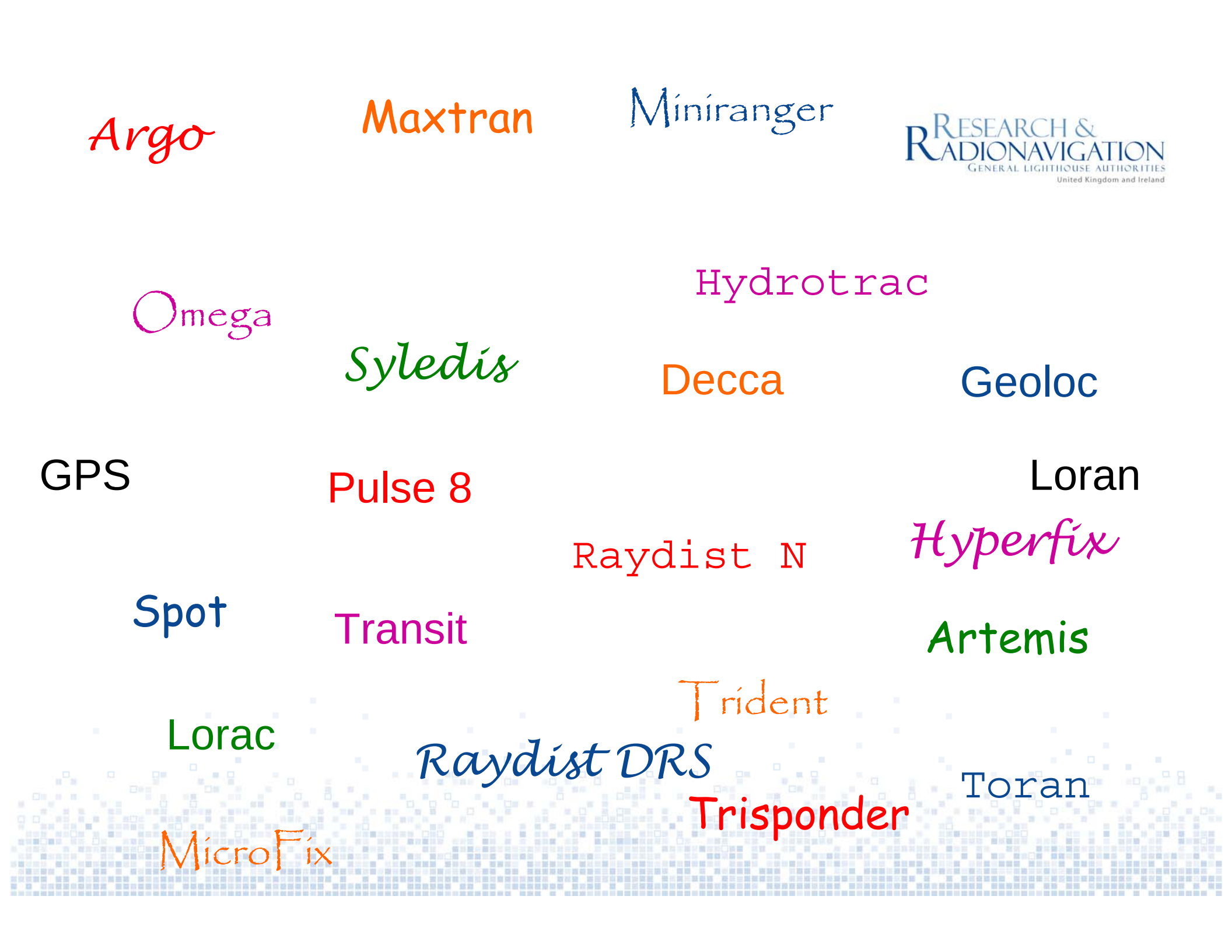
Energy & Communications

Positioning, Navigation & Timing




Argo
Maxtran
Miniranger
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Hydrotrac
Omega
Syledis
Decca
Geoloc
GPS
Pulse 8
Loran
Hyperfix
Raydist N
Spot
Transit
Artemis
Trident
Lorac
Raydist DRS
Toran
Trisponder
MicroFix

Source: www.apple.com

GPS is vulnerable at system, signal and user levels

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	Vulnerability Examples	Possible Mitigation
System	**Satellite clock failures** (e.g. SVN23, 1 Jan 2004)	**Second system or augmentation** (e.g. Galileo, eLoran, SBAS)
	Poor signal quality (e.g. evil waveforms)	**Second system or augmentation** (e.g. Galileo, eLoran, SBAS)
	Design flaws (e.g. Block IIR ranging code interruptions)	**Second system or augmentation** (e.g. Galileo, eLoran, SBAS)
Signal	**Intentional interference** (e.g. potential terrorism)	**Second dissimilar system** (e.g. eLoran)
	Unintentional interference (e.g. Moss Landing)	**Second system, other GNSS frequencies** (e.g. e-Loran, L2C, L5)
	Ionospheric effects (e.g. scintillation at high latitudes or equator)	**Second dissimilar system** (e.g. e-Loran)
User	**Equipment malfunction** (e.g. Royal Majesty, 1995)	**Second dissimilar system (e.g. eLoran)**
	Signal occultation (e.g. Urban canyons)	**More SVs &/or second dissimilar system** (e.g.Galileo, SBAS, eLoran)
	Local Interference (e.g. Manatoulin TV set)	**Improved siting &/or second dissimilar system**

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End-to-end civil GNSS

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Inherently reliable	✗
Secured against obvious external threats	✗
Capable of withstanding some damage	✗
Robustness	✗
Redundancy	?
Resourcefulness	✗
Rapidity	✗

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	Map Matching	Inertial Nav. System	Atomic Clock	eLoran
Cost-effective to User	✓	✗	✗	✓
Cost-effective to State	N/A	N/A	N/A	✓
PNT	P	PN	T	PNT

GNSS + eLoran

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- Inherently reliable ✓
- Secured against obvious external threats ✓
- Capable of withstanding some damage ✓
- Robustness ✓
- Redundancy ✓
- Resourcefulness ✓
- Rapidity ✓

Delivering a reliable, efficient and cost-effective AtoN service for the benefit and safety of all mariners