



Non-Inertial Navigation In 21 Century and Beyond

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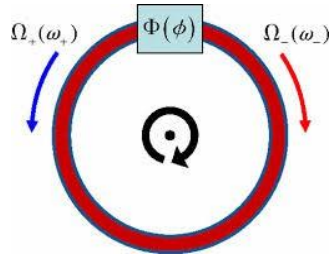
I hate GPS” – Secretary of Defense Nominee Ashton Carter

by [Editor](#) | Dec 30, 2014 | [Blog](#)

“**I hate GPS**” Ashton Carter, president Obama’s nominee for Secretary of Defense, told a reporter, just a few weeks ago. The good Mr. Carter suggests in his interview that, in 20 years our dependence on satellites will be eliminated by **new chip clocks, gyros and accelerometers.**

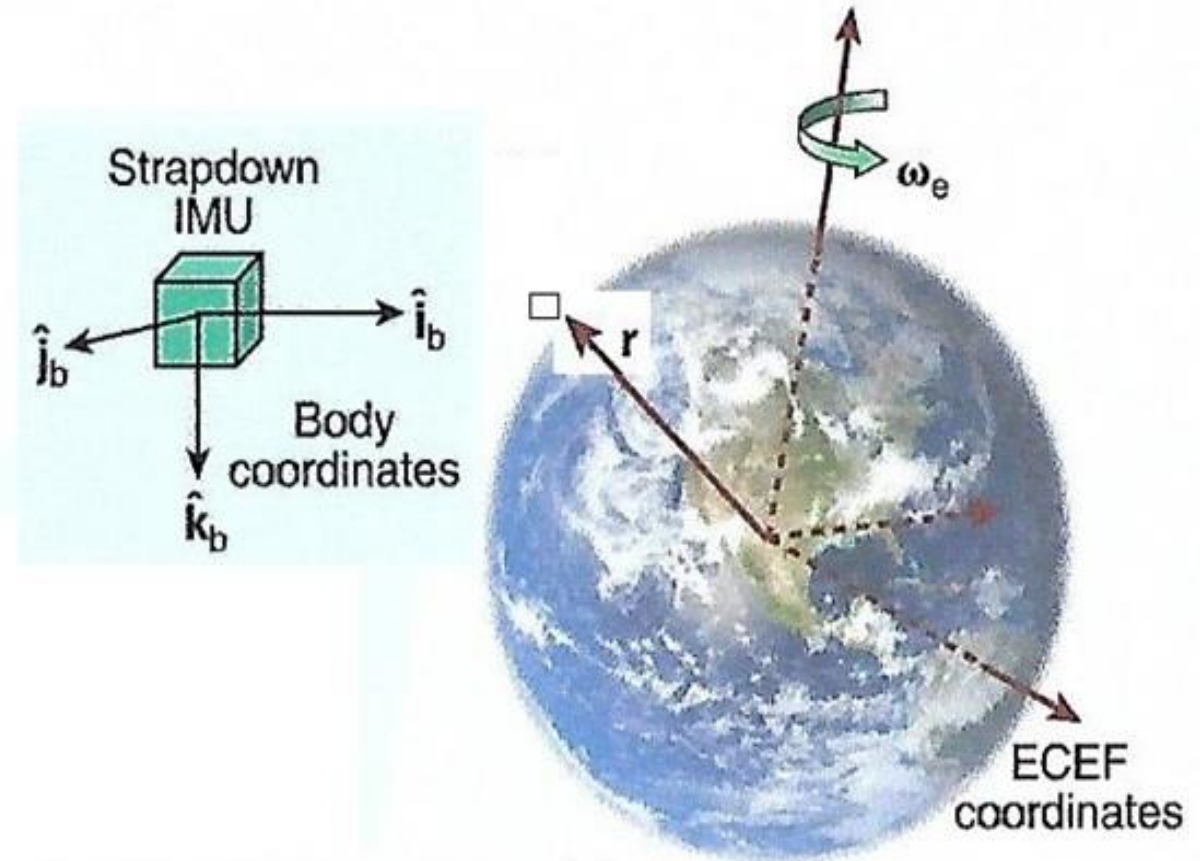
Continued research is good, but we can’t wait 20 years. The father of GPS, Dr. Brad Parkinson, has called our dependence upon GPS: “**a single point of failure**” and America’s “**largest unaddressed critical infrastructure problem.**”

Unfortunately, not everyone in government and industry understands the problem, and the need to move quickly to implement a Technology that is proven and immediately available.



INHERENT LIMITATIONS:

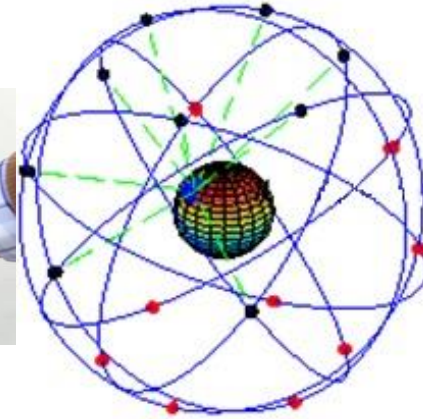
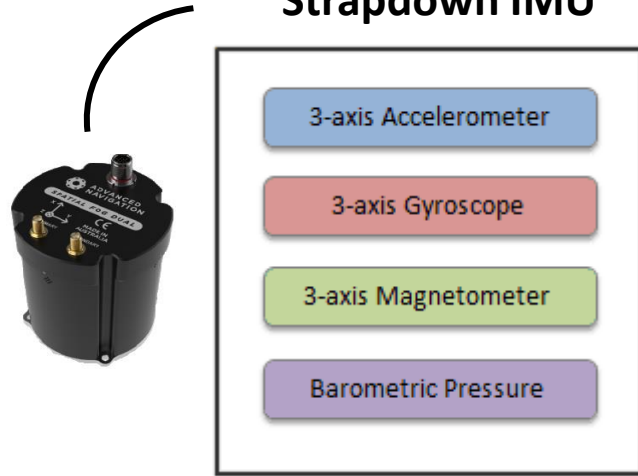
- **MOMENTUM OF ROTATION**
- **MEASURE ACCELERATION**
- **NON-LINEAR SYSTEM**
- **REQUIRES INPUT OF GRAVITY**
- **RANDOM WALK**
- **DRIFT**
- **LATENCY**
- **CUMULATIVE ERROR EFFECT**



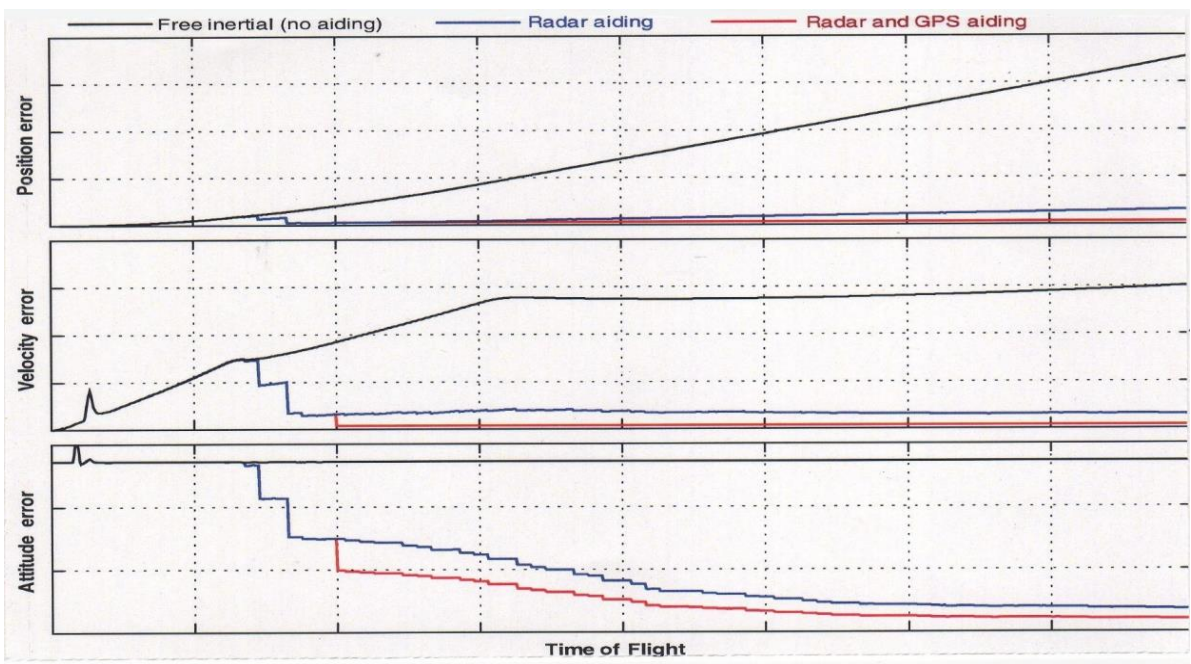
IMU - GPS Coordinates Transformation

Position Navigation and Timing

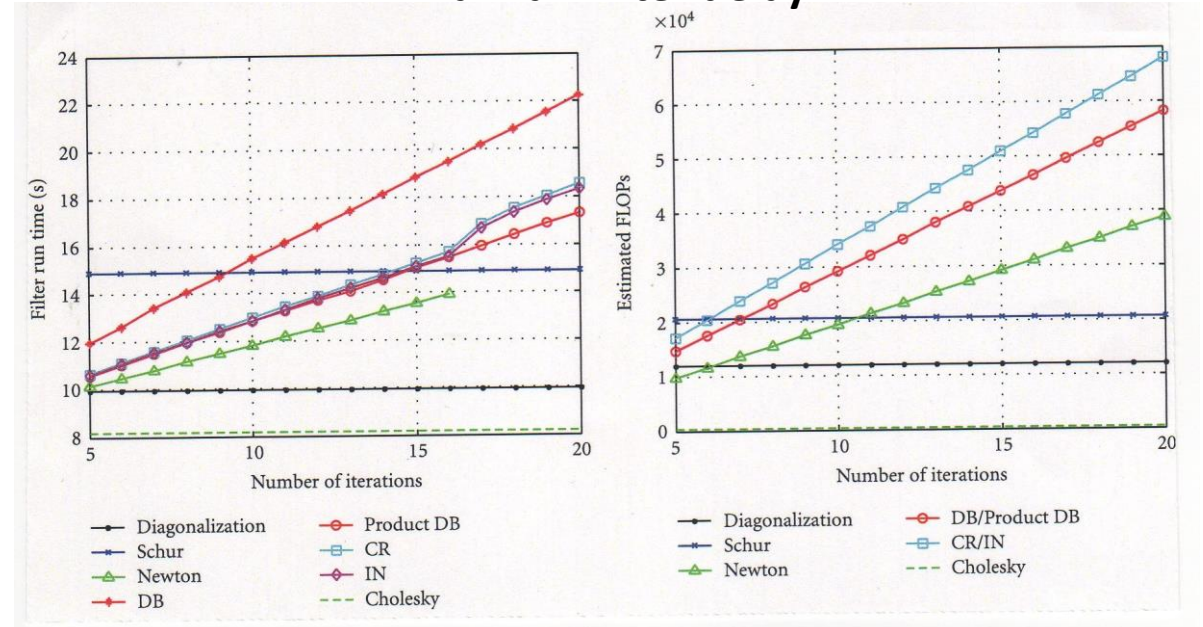
Strapdown IMU



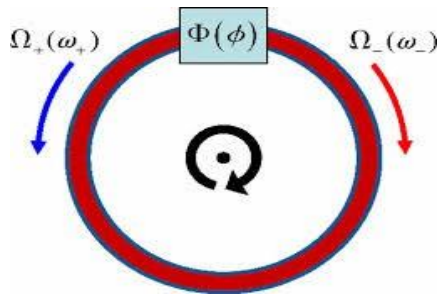
GPS



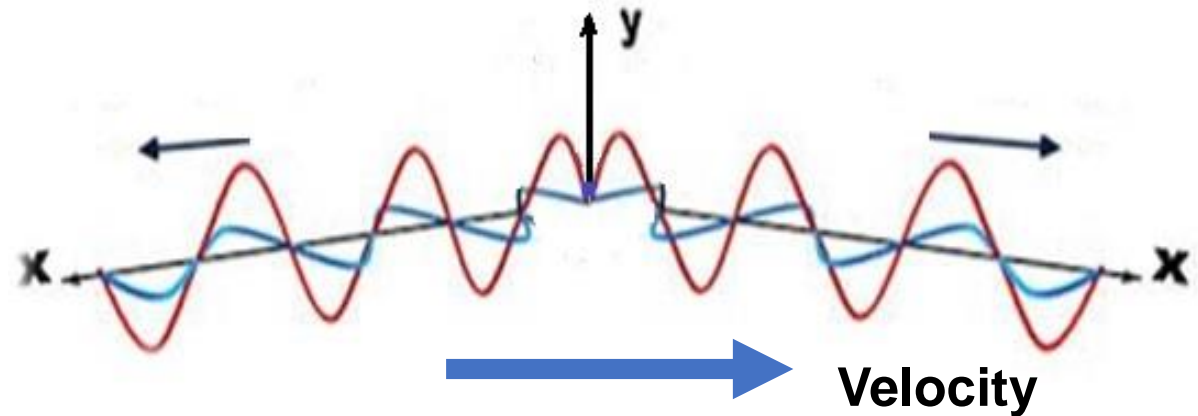
Kalman Filter delay



Contrary to the functionality of the Fiber Optic Gyro or Laser Ring Gyro, which are based on Sagnac effect of propagation of light in the body under rotation
 The TONIN devices are collinearly measuring displacement of the object in relation to the propagation of light within.



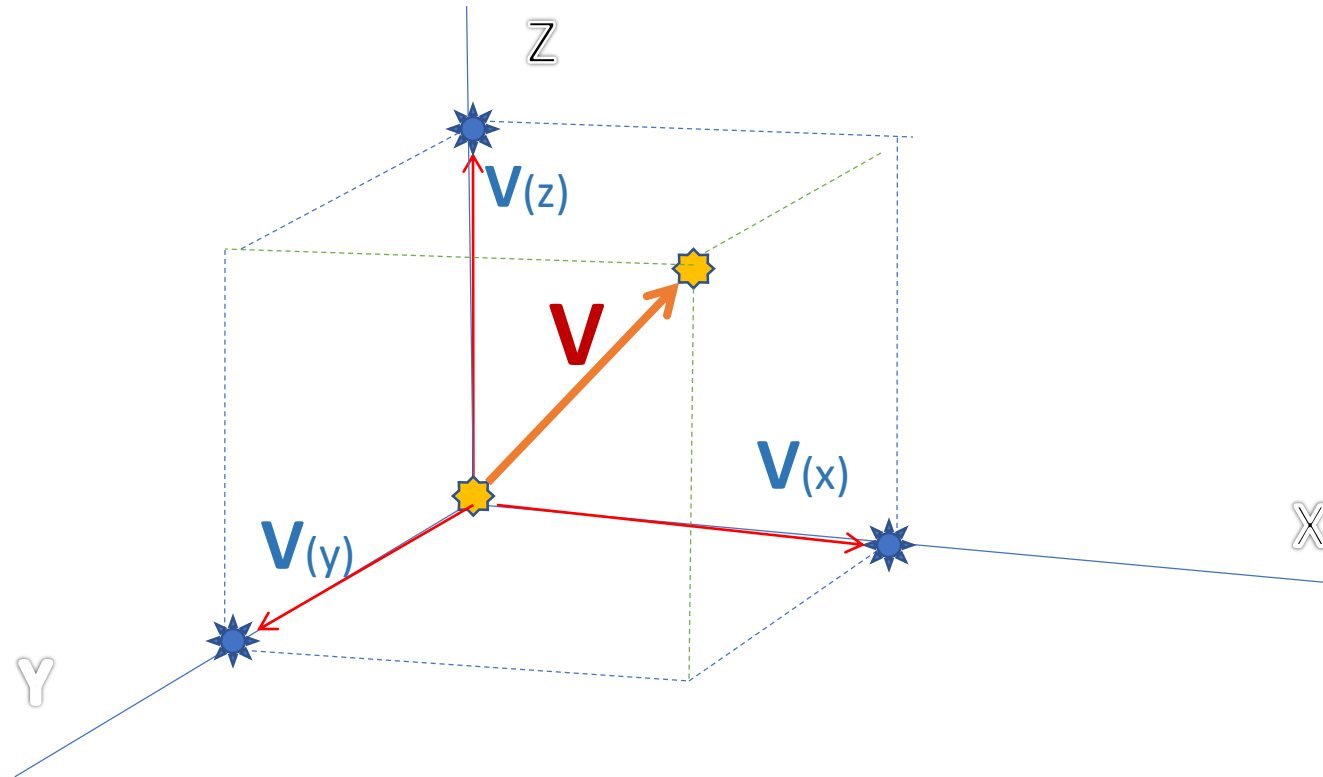
Sagnac Effect



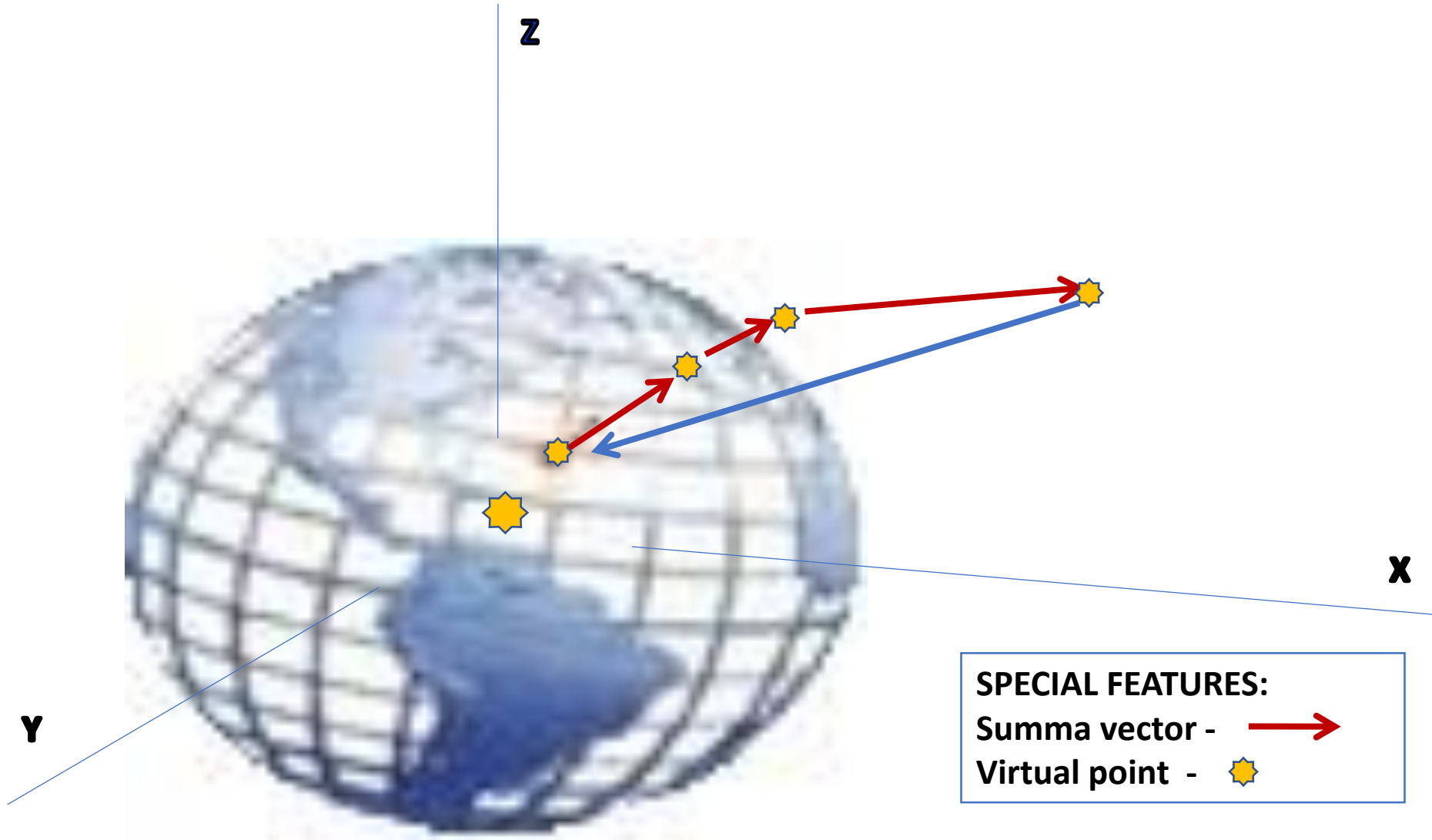
Michelson Collinear Method

The technically developed capability of measuring velocity of an object from within and from the motion itself became the foundation of the Technology of Non-Inertial Navigation (TONIN)

3-D Summa Velocity Vector

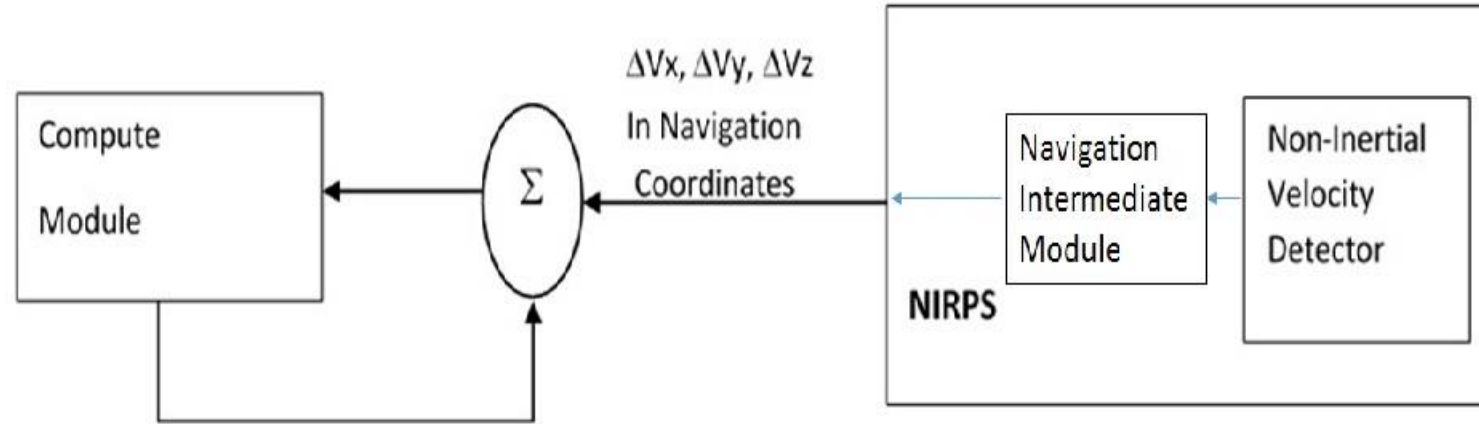


DIGITIZING FLIGHT TRAJECTORY IN 3-D SPACE



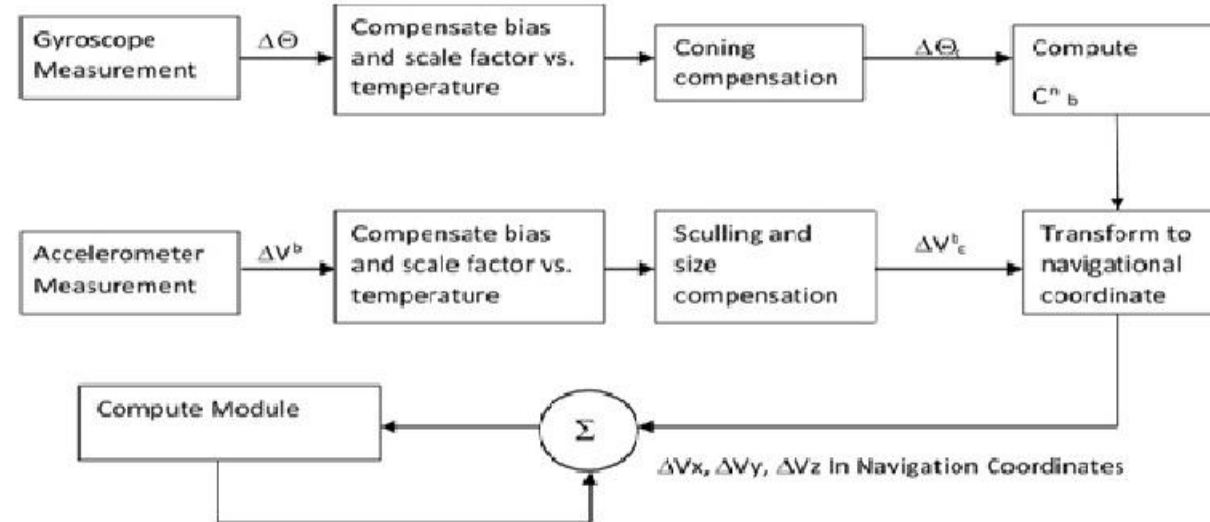
Navigation Independent Relative Positioning System (NIRPS) in Action

NIRPS



VS

**Strapdown
IMU**



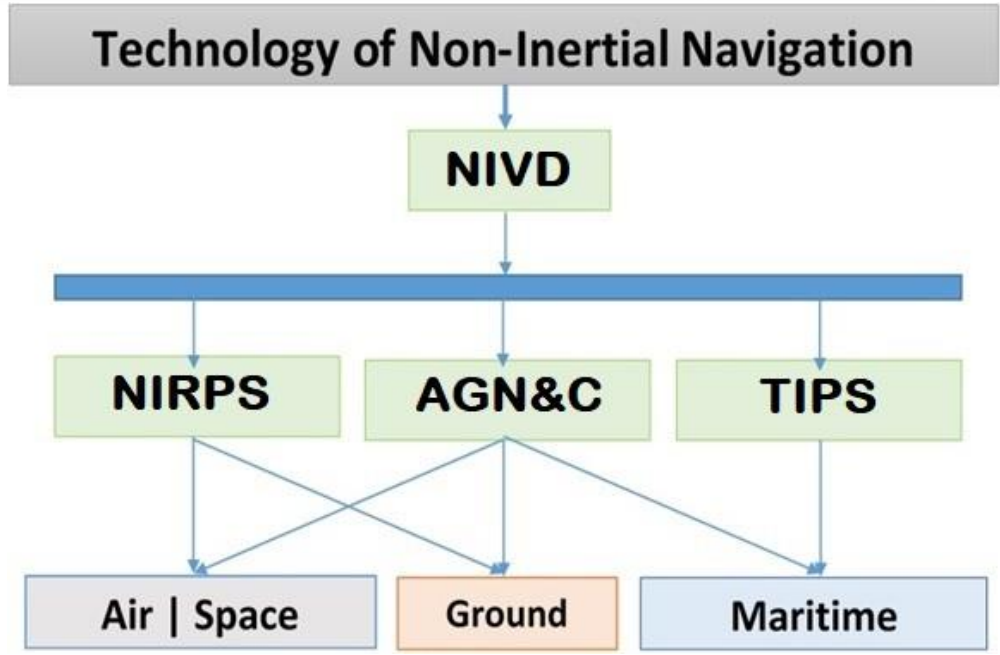
Framework of the TONIN Development

Technology

Subsystem

Systems

Area of Application



Acronyms:

- **TONIN - Technology Of Non-Inertial Navigation**
- **NIVD - Non-Inertial Velocity Detector**
- **NIRPS - Navigation Independent Relative Positioning System**
- **AGN&C - Autonomous Guidance Navigation and Control System**
- **TIPS - Terrestrial Independent Positioning System**

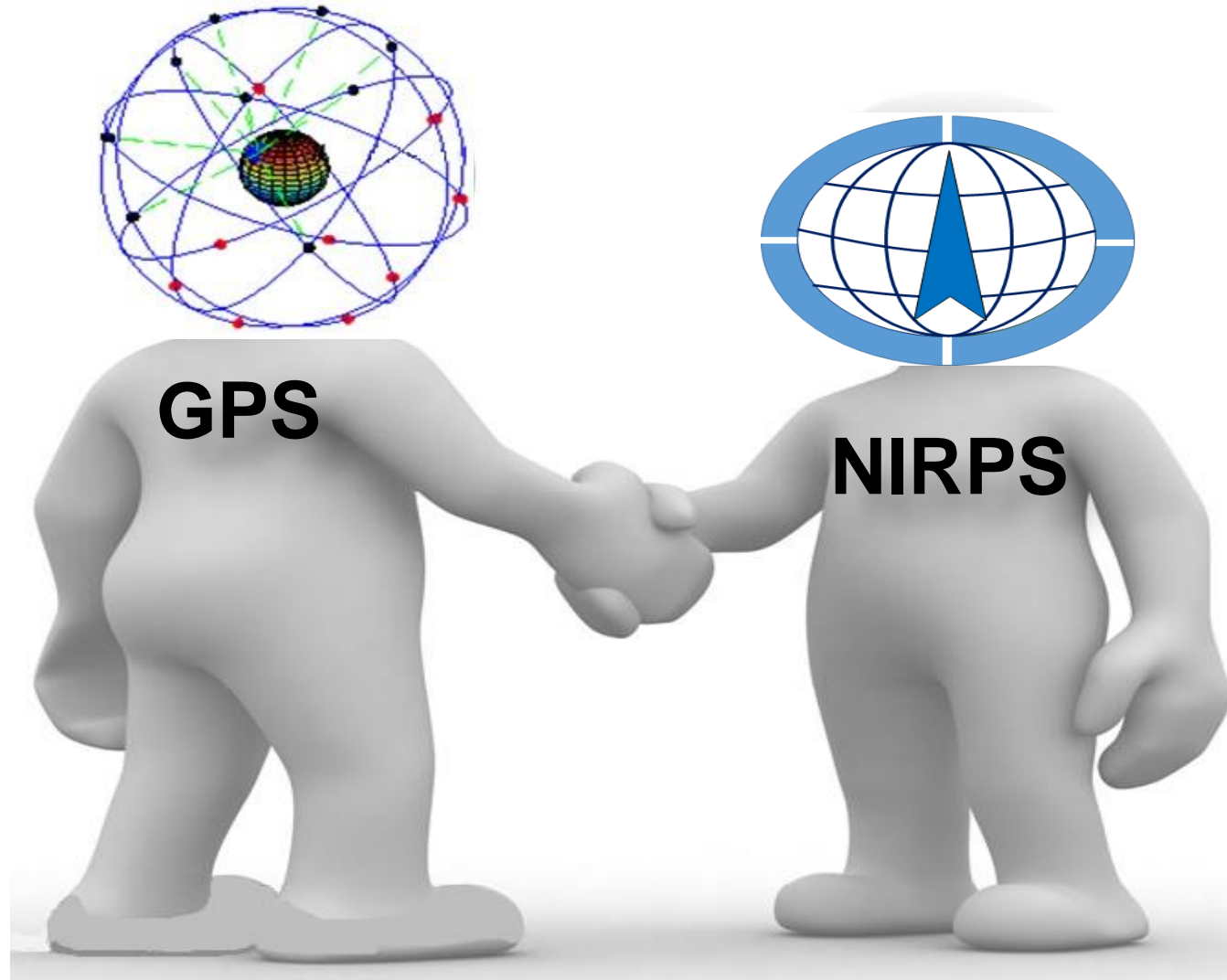
NIRPS vs. IFOG/GPS

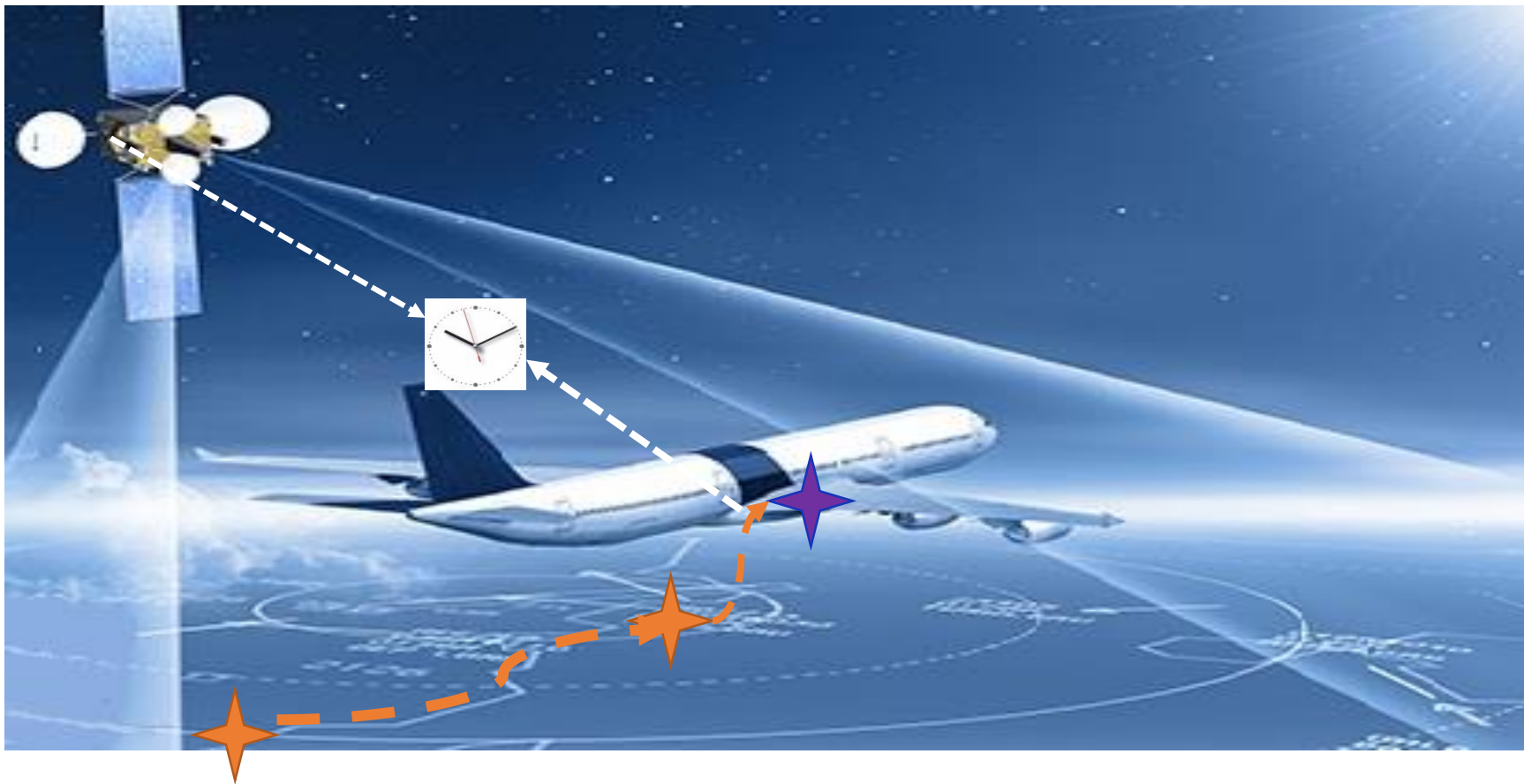
| Parameters | NIRPS | IFOG/GPS |
|-------------------------------------|----------------------------|-------------------------|
| Packaging | Sealed | Partially sealed |
| Measurement | Velocity | Acceleration |
| Accuracy | 9m/sec | 5m/sec ² (*) |
| Hardware response time | 0.2 x10 ⁻³ sec. | 1.5sec – 10sec(**) |
| Integration drift | 0 | ~ 30 °/hr. |
| Complexity | Low | High |
| Accuracy grade | Marine | Navigation |
| Coverage of anti-access/area denial | 100% | 0 |
| Cost of Maintenance | 0 | High |

(*) 5m/sec² acceleration is currently best possible for all forms of Gyro navigation

(**) Low number reflects response of INS; High number reflects min. response of INS/GPS

Position thru Navigation (PTN)





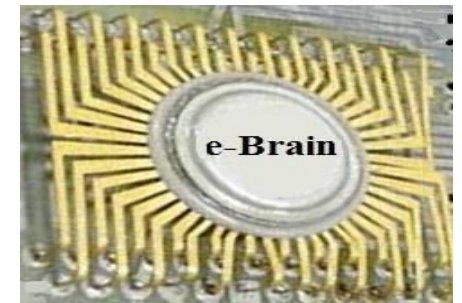
NIRPS will provide continuous detail information of the flight trajectory, which will allow to recall and match it with the Kalman' delayed positional information of the airplane.



TONIN systems will be calibrated in relation to the Earth axis (similar to GPS), therefore it will be straight forward transition from one system to the other. GPS-NIRPS will form a reliable interoperable mutual backup system that will negate any natural and human interference.

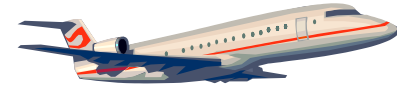
The TONIN based onboard AGN&C System will:

- Provide onboard real-time independent 3D Velocity Vector;
- **Respond** on 3D Velocity Vector, in accordance with control modes during mission phases, by updating the systems changes and resetting the coupling with the vehicle systems management tools during the execution;
- **Resolve** choices on its own, including onboard autonomous mission execution and planning as well as Fault Detection, Isolation, and Recovery (FDIR) process.





Safe Sky Programs



A flight path of any type of an airplane will be electronically entered into the nationwide or international computerized flight control system and locked under security codes into the “Flight Card”.

By inserting the “Flight Card” into AAAN system the pilot will automatically initiate flight operation based on GPS/NINT input.



Any changes to the flight path can be quickly made from joint input of a pilot’s password and control tower permission.

“Safe Sky” Program will prevent any 9/11 type disasters, midair collisions, unintentional loss of control, and other air tragedies.

Autonomy is the Key to Unmanned Operations

The Achilles heel of any current Manned and Unmanned Flight Control System resides in the two critical areas:



- Latency of gyro navigation
- Dependence on outside information that is provided remotely via RF means under continuous assault by natural and manmade interferences

The fully functional TONIN Autonomous Systems will provide reliable onboard Navigation that is independent from outside sources, along with the ability to guide and control all essential onboard functions when GPS is not available.

Deep Space Navigation

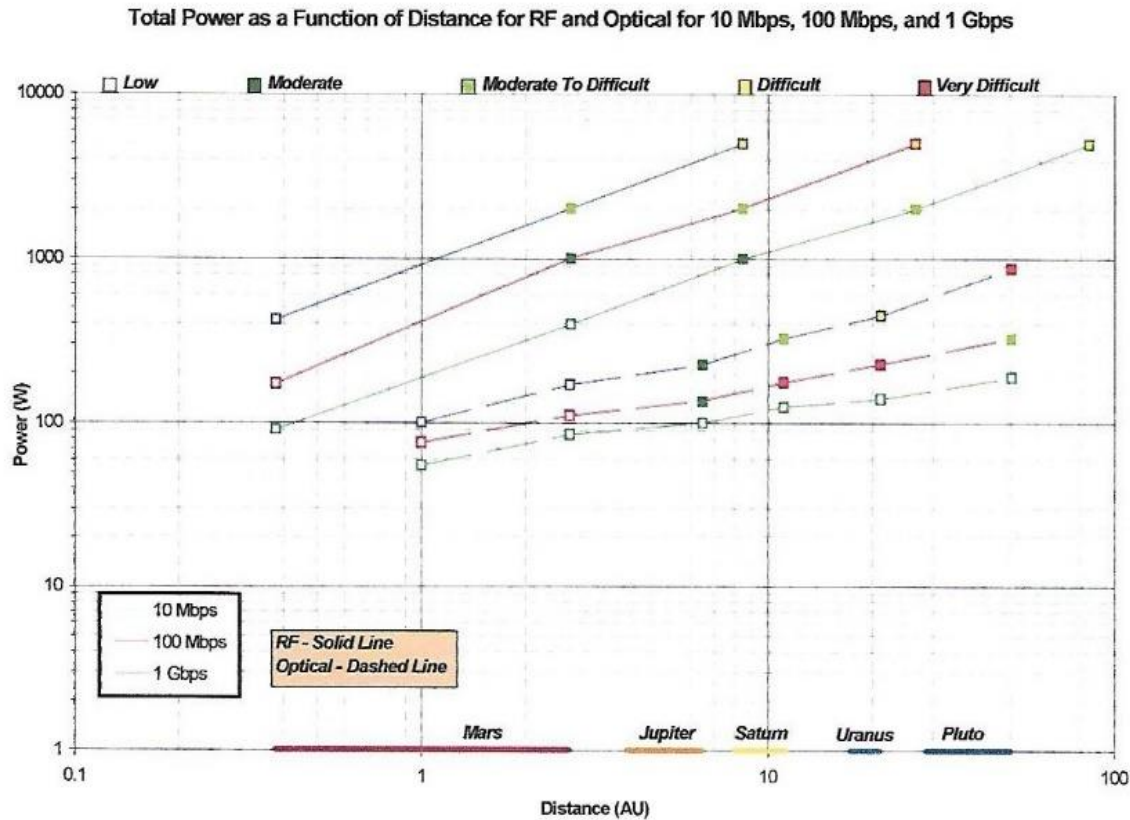


Figure 3: Total Power as a Function of Distance for RF and Optical Systems in the 2020 Timeframe.

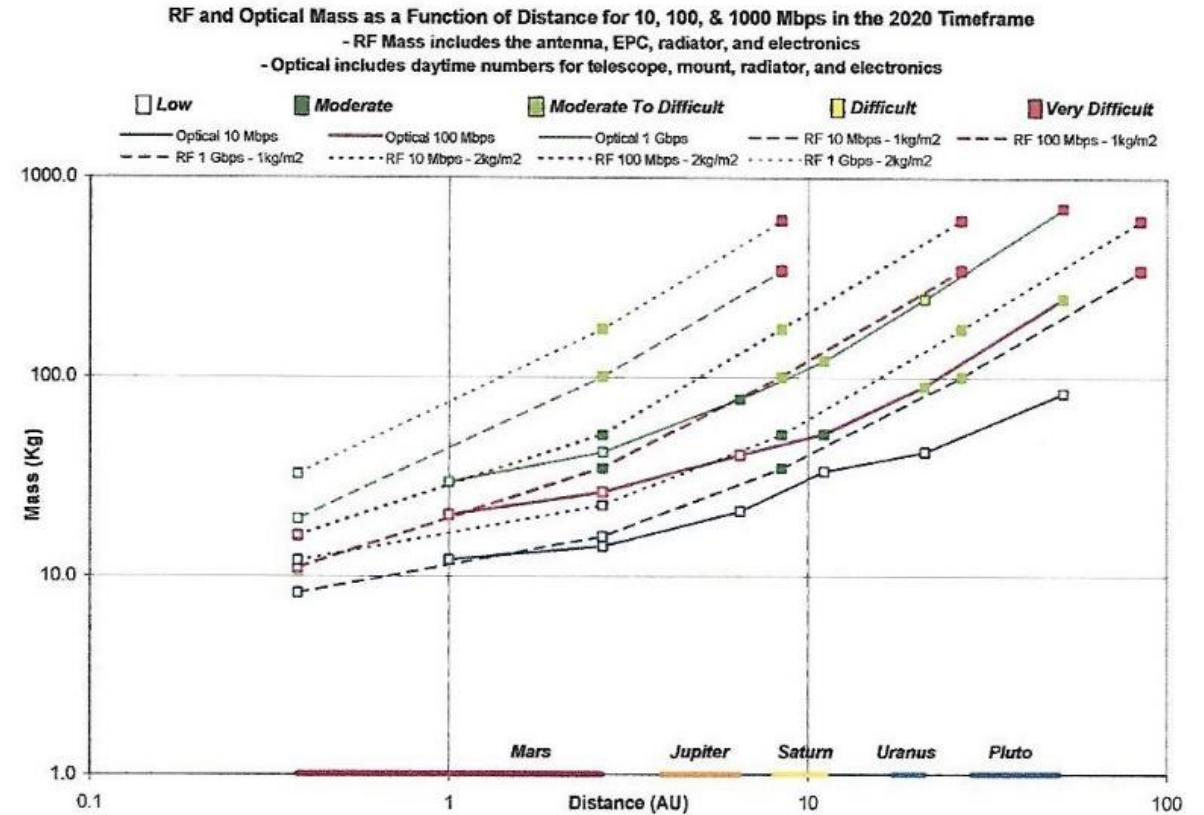
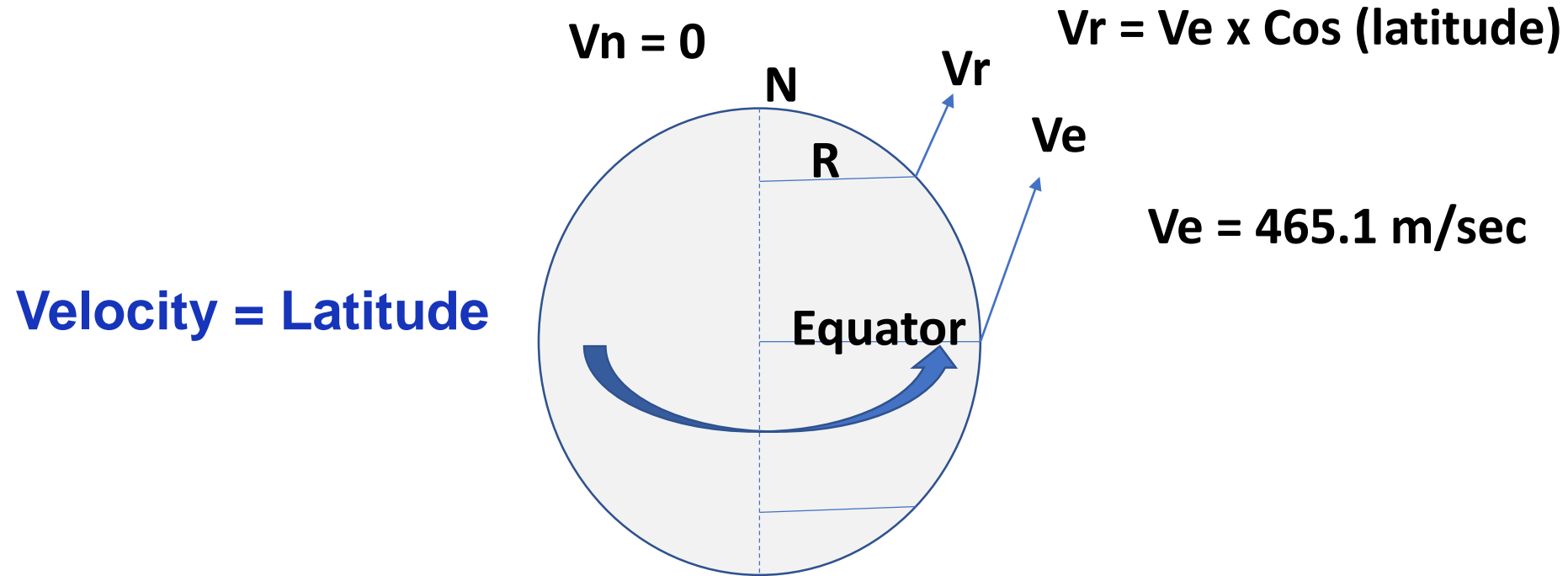


Figure 2: The RF Mass and Optical Mass are given as a function of distance and data rate.

Light travels 1AU in 8.3 min

With current bandwidth of 5.2 megabits per second, it took the Mars reconnaissance satellite about 1.5hrs to unload a single image back to the ground station



TIPS utilizes the combination of the two most trusted phenomena of nature:

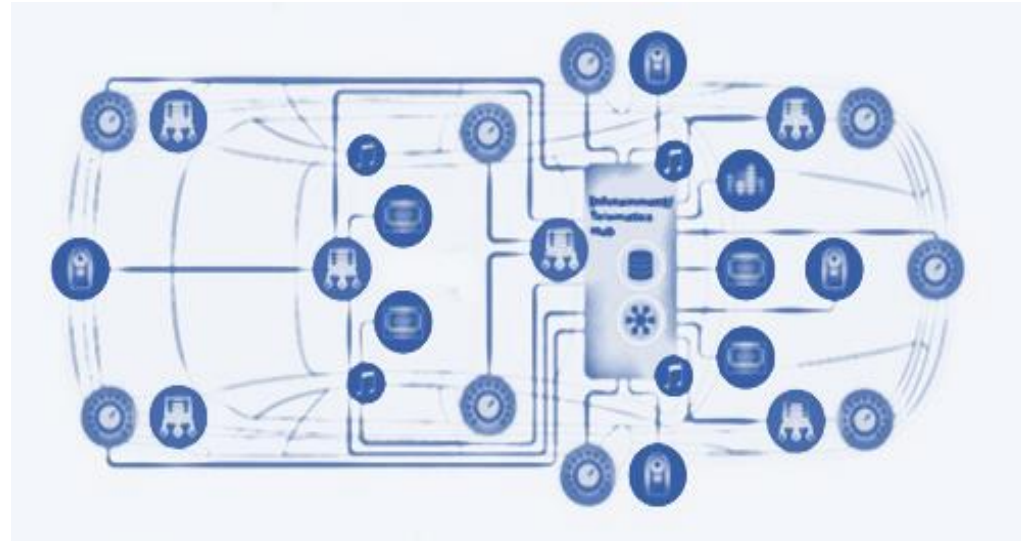
- The independent, constant velocity of light
- The constant axial rotation of the Earth

“Cybersecurity protects the operation of the self-driving system and other critical vehicle systems from malicious interference and supports high customer confidence in our vehicle’s operation and use.”

-Self-driving Safety Report, 2018 - General Motors-



Rendering:
Photonic Integrated Circuit of the
Non-Inertial Velocity Detector -Single Axis



Addition of the Non-Inertial Velocity Detector (NIVD) System to the current electronic system of autonomous vehicles will provide timely Positioning and reliable Cybersecurity when GPS is not stable or not available.

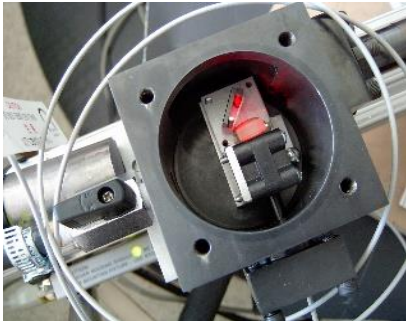
TIPS provide in real-time information on location, spatial orientation, and heading for terrestrial crafts with marine grade resolution that is independent from outside sources, including GPS.



TIPS concentrate all vital navigational information in the visual format of Active Unified Interface (AUI) Display, that could be utilized for the Outer Space Navigation.

Progression in the Development of TONIN Devices

**IVD
Models**



2011

**TVD
Models**



2014

**NIVD
Heterodyne
Model**



2017.....2021

**NIVD-SA
Prototype**





The key to the development of the TONIN systems resides in the successful fabrication of the Photonic Non-Inertial Velocity Detector Single-Axis (NIVD-SA). The photonic methods of fabrication will provide required stability of parameters in conjunction with the cost benefits from mass production

Conclusions

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- **The functionality failure of the current IMU-GPS arrangement resides in inherent limitations of Gyro Navigation.**
- **The deployment of the TONIN Systems eliminates the shortfalls of the Inertial Navigation.**
- **The capability of the TONIN-Technology continuously and autonomously measure Space-Speed Velocity provides for a wide range of opportunities in Aerospace and Terrestrial Applications.**
- **The proposed GPS-NIRPS a reliable interoperable mutual backup systems arrangement, assures the Cybersecure Reliable Real-time Navigation.**
- **Position Thru Navigation (PTN), is the conclusive solution to the current PNT problems.**