

***ION Outreach Committee***  
***ION Virtual Navigation Museum***

**ION Southern California Section Meeting**  
**December 16, 2008**  
**Torrance, CA**

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# ***ION Virtual Navigation Museum OUTLINE***

- **ION Virtual Navigation Museum (VNM)**
  - **Background**
  - **Policies and Procedures**
  - **Organization**
  - **Some Interesting Items**
  - **Status and Plans**
  - **How to Submit an Item?**
  - **Invited Items**
  - **Conclusions**

# ***ION Virtual Navigation Museum Background***

- **ION VNM approved by ION Council in January 2004**
- **ION Outreach Committee (Ad hoc) approved by ION Council, June 2004**
  - **Tasked to develop, and establish the ION Virtual Navigation Museum (VNM).**
- **Developments involved:**
  - **Developed web site**
  - **Web-based and Form-based submission & review process implemented**
  - **Editorial Review Board established & expanded**
  - **ION VNM Policy & Procedures document established**
  - **Increased public awareness of the ION VNM**
    - **ION Newsletter publications**
      - **Bartone, C., "Making the Virtual (Museum) Real, ION Newsletter, Volume 16, Number 2, Summer 2006**
      - **Bartone, C., "From Sextants to Digital GPS Receivers: The Virtual Navigation Museum Invites Submissions, ION Newsletter, Volume 18, Number 2, Summer 2008**
    - **ION GNSS 2006 and ION GNSS 2007 booth**

## ***ION Virtual Navigation Museum Background (Cont.)***

- **Collaboration efforts with physical museums established:**
  - Smithsonian Institution, Washington, DC
  - The Mariners' Museum, Newport News, Virginia
  - Maritime Museum of Monterey, Monterey, CA
- **ION VNM made public at ION GNSS 2006 and accessible from [www.ion.org](http://www.ion.org) on Oct 5, 2006.**
  - IOC declared
- **ION Outreach Committee made ION Standing Committee by ION Council, April 2007.**

# ***ION Virtual Navigation Museum Policy & Procedures***

## **ION VNM Policy & Procedures in two major sections:**

### **I. Collecting Policy**

- **Identifies general categories for submissions**
- **Identifies mission areas for submissions**
- **Addresses physical museum collaboration**
- **Puts forward a scope of what items are and are not suitable for inclusions into the ION VNM**
- **Documents Collection Evaluation by ION VNM Editorial Advisory Board**

### **II. Collection Development Plan**

- **Identifies general categories for submissions**
- **Identifies mission areas for submissions**
- **Categories will be expanded upon as the ION VNM matures and entries of significant are placed for viewing**
- **Contains list of desired collection items**

## ***ION Virtual Navigation Museum*** **Policy & Procedures - Collection Policy**

**For inclusion into the ION VNM, navigation related items should be:**

- **of national and/or international historical importance in themselves or by association (e.g. story with national or international impact; cutting-edge material; significant provenance)**
- **the best of its kind (a developmental milestone; related to a leader in the field; inspirational)**
- **Items of contemporary use which have extraordinary future research potential.**
- **Commonplace navigation items that had a significant impact on how people navigate.**

**The ION VNM will not include manufactured items to promote commercial products. Additionally, the museum will typically not display items that are similar without major distinction or improvement.**

# ***ION Virtual Navigation Museum Organization***

- **Current categories provide a framework for navigation related artifacts as they relate to:**
- **APPLICATIONS where navigation takes place:**
  - Aviation
  - Marine
  - Land
  - Space
- **METHODS used in navigation:**
  - inertial navigation
  - Celestial (e.g, optical) navigation
  - radio navigation (terrestrial and satellite)
- **TECHNOLOGIES for navigation:**
  - Systems
  - Components
  - Documents
- **Categories are not fixed and fully populated**
- **New categories will evolve and expand to meet items submitted and suitable for inclusion**

Ref: [www.ion.org/museum](http://www.ion.org/museum), date visited Dec 14, 2008



The Institute of Navigation

# Navigation Museum

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SEARCH
MUSEUM LINKS
Submit an Item

## Welcome to the ION Virtual Museum!

The Institute of Navigation is a non-profit professional society dedicated to the advancement of the art and science of navigation. The ION also recognizes the importance of preserving previous art and science in navigation. In June 2004, the ION approved the establishment of an ION Virtual Museum to help preserve this past.

Rather than a physical museum, this virtual museum allows visitors to read descriptions, view photographs, and obtain detailed information on devices, systems, components, and/or methods in a convenient electronic format. In some cases physical artifacts are rare or not available; this virtual museum allows the visitor to obtain information on these artifacts. For actual artifacts on display, the locations are listed on most pages to allow interested participants to visit them.

To begin, select a category below or from the menu at left.

<a href="#">Aviation</a>	Aviation related items
<a href="#">Marine</a>	Marine related items
<a href="#">Land</a>	Land applications
<a href="#">Space</a>	Space Navigation
<a href="#">Inertial</a>	Inertial Navigation Systems
<a href="#">Celestial</a>	Celestial Navigation
<a href="#">Radio Navigation (Satellite)</a>	Satellite radio navigation systems and equipment
<a href="#">Systems</a>	System Descriptions
<a href="#">Components</a>	Components
<a href="#">Documents</a>	Archival Documents

## [Submit your item to the Navigation Museum!](#)

Do you have something that belongs in the ION Navigation Museum? Sharing your



***ION Virtual Navigation Museum***  
**Some Interesting Items**

**Go to live [www.ion.org/museum](http://www.ion.org/museum) if available**




**ION VNM**  
**Some**  
**Interesting**  
**Items:**  
**GPS**

Ref: [www.ion.org/museum](http://www.ion.org/museum),  
date visited Dec 14, 2008

 The Institute of Navigation  
**Navigation Museum**

[Radio Navigation \(Satellite\) > GPS >](#)

Select from the options below:

-  [All-Digital GPS Receiver Development](#)
-  [Generalized Development Model \(GDM\)](#)
-  [GPS 12](#)
-  [Klobuchar's Algorithm for Ionospheric Corrections](#)
-  [Magnavox X-Set](#)
-  [Rockwell Manpack Global Positioning System \(GPS\) Receiver](#)
-  [Rockwell PLGR](#)
-  [Texas Instruments TI 4100 NAVSTAR Navigator](#)

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SEARCH

MUSEUM LINKS

- Submit an Item

# ION VNM Some Interesting Items: GPS Magnavox X-Set

Ref: [www.ion.org/museum](http://www.ion.org/museum),  
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SEARCH

MUSEUM LINKS

Submit an Item

[Systems](#) > [GPS](#) > Magnavox X-Set

## Magnavox X-Set




Date manufactured: 1974-1975

**Period/Dates when in use:** In 1974 the GPS JPO issued contracts for the Space, Control and User Equipment Segments for the GPS Phase 1 Validation Phase. This Phase was to validate the performance objectives of Navigation Accuracy. In addition to performance these included an extensive list of demonstrations of Military Value. These demos were critical since the DOD had not shown much interest in GPS until this point in time.


**Description:** The elements of the X-Set shown in Figure 1 were an X Receiver, a Data Processor with a software program loader (Philips cassette), a Power Supply designed for both 400Hz and 28V DC power, a Battery Backup, a Control Display that had, in addition, the ability to load program patches thru the keyboard, a Pilot Steering Display and a Preamplifier. The equipment shown in Figure 1 dissipated over 700 watts and weighed 700 lbs. The data processor alone weighed 150 lbs and dissipated 500 watts. This was characteristic of the parts available in the 1974-5 timeframe. X Receiver The X Receiver was a 4 Satellite/Pseudolite continuously tracking receiver designed to meet the full performance specifications including jamming and had the ability to track to high levels of jamming when aided. The X Receiver's functional design had the ability to use two antennas and to use either L1 or L2 for each channel. This mode of operation had 4 channels tracking carrier signals and the fifth channel time-sharing code tracking. The mode changed to code tracking with high jamming. The X Receiver was substantially a digital design and samples were transferred to the Process Controller (PC), part of the receiver, at a 1 KHz rate where all of the signal processing was done in software. Magnavox built the PC from available computer chips (ALU, RAM, ROM and I/O) and micro coded to emulate the Hewlett Packard 2100 minicomputer family.

*Additional text here cut for slide*

**Additional Photos:**



[Figure 1. Magavox X-Set without IMU](#)




[Figure 2. Military Demo Results](#)

**For More Information, Contact:**  
Vito Calbi  
[vitalcalbi@mac.com](mailto:vitalcalbi@mac.com)  
626-683-9040

**ION VNM**  
**Some**  
**Interesting**  
**Items:**  
**GPS**  
**GPS 12**

Ref: [www.ion.org/museum](http://www.ion.org/museum),  
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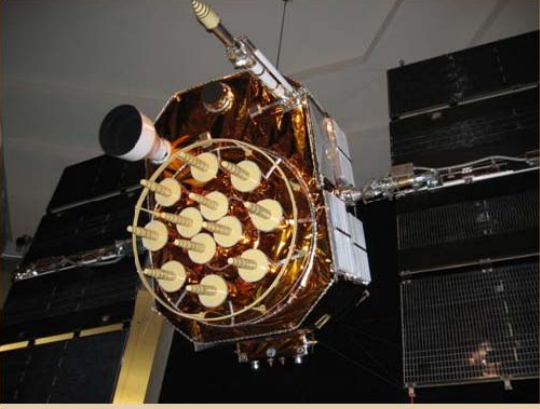
SEARCH

MUSEUM LINKS

Submit an Item

[Systems](#) > [GPS](#) > GPS 12

## GPS 12




**Date manufactured:** 1983-1984


**Description:** The GPS-0012 satellite was the Qualification Test Vehicle (QTV) for GPS Block II production program and never was intended to fly in space.

**Item History:** This satellite originally started as one of the last four Block I Replenishment Satellites, GPS-0009 through 0012, hence the name GPS-0012. During the transition of the GPS from a development to production program, the Navstar GPS Joint Program Office (JPO) received permission to convert the last GPS Block I Replenishment satellite into a Block II QTV to reduce risk and save program cost. The then recently approved MIL-STD-1540 was imposed on the GPS Block I, then subsequently to the Block I Replenishment and Block II production contracts. MIL-STD-1540 provided the option to either build and qualify an entire space vehicle or very much later use a delta-qualification approach (now known as proto-qualification). The Air Force chose to implement the more expensive option of a full QTV on both Block I and Block II. Most satellite programs, to include GPS Blocks IIR and IIF use the proto-qualification concept today to save cost.


**Additional Photos:** *Additional text here cut for slide*



[GPS 12 Satellite in STS for Integration Test](#)



[GPS 12 Satellite on display at San Diego Air and Space Museum](#)



[Dr. Ivan Getting with GPS 12 in loading dock](#)

**Location/Ownership:**  
[San Diego Air & Space Museum](#)  
 San Diego Air & Space Museum  
 2001 Pan American Plaza, San Diego CA 92101

**For More Information, Contact:**  
 San Diego Air & Space Museum  
[dsharp@sdasm.org](mailto:dsharp@sdasm.org)  
 (619) 234-8291 Ext. 62

# ION VNM

## Some Interesting Items:

### GPS

### TI 4100

### NAVSTAR

### Navigator

Ref: [www.ion.org/museum](http://www.ion.org/museum),  
date visited Dec 14, 2008



The Institute of Navigation

# Navigation Museum

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MUSEUM LINKS

Submit an Item

[Systems](#) > [GPS](#) > Texas Instruments TI 4100 NAVSTAR Navigator

### Texas Instruments TI 4100 NAVSTAR Navigator



Photo courtesy of NOAA/NGS

**Model number:** TI 4100

**Date manufactured:** ~1981

**Description:** The Texas Instruments TI 4100 NAVSTAR Navigator (TI 4100) was the first commercial Global Positioning System (GPS) receiver.

**Item History:** The TI 4100 was first offered for sale circa 1981 when there was only a test constellation of GPS Block I space vehicles (SVs). The TI 4100 was a third generation GPS receiver. The design was based on custom large scale integrated (LSI) components that were originally intended for military applications. The LSI technology was integrated injection logic (I<sup>2</sup>L). I<sup>2</sup>L was the highest speed low-power bipolar digital technology of that time period. A geodetic version of the TI 4100 evolved from a tri-agency contract administered by Applied Research Laboratory of the University of Texas and funded by the Defense Mapping Agency, National Geodetic Survey and the U.S. Geological Survey. The geodetic versions were delivered in pairs with phase matched antennas plus calibrated receiver characteristics. The basic TI 4100 configuration included an antenna/preamp assembly, the receiver, and a control display unit (CDU). There was also an optional dual-drive cassette recorder. Another option supported customer reprogrammable navigation. Navigation error (typical 4 SV): 14 m P code, 47 m C/A code, 0.015 m/s velocity.



[TI 4100 Navstar Navigator Brochure \(Courtesy of TI\)](#)



[TI 4100 Geomark Relative Positioning Software Brochure \(Courtesy of TI\)](#)

**Submission authored by:**  
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**ION VNM**  
**Some**  
**Interesting**  
**Items:**  
**Inertial**  
**Aviation**

The Institute of Navigation  
**Navigation Museum**

[Inertial](#) > [Aviation Inertial](#) >

Select from the options below:

-  [Autopilot Gyroscope](#)
-  [Electrically Suspended Gyroscope](#)
-  [GAM-77/AGM-28 Hound Dog Missile Guidance System](#)
-  [Vertical Gyroscope](#)

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**ION VNM**  
**Some**  
**Interesting**  
**Items:**  
**Maritime**  
**Celestial**

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[Marine](#) > [Maritime Celestial](#) >

Select from the options below:

-  [Back-staff](#)
-  [Cross-staff](#)
-  [Gunter's quadrant](#)
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-  [Octant](#)
-  [Pendulum Sextant](#)

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# ***ION Virtual Navigation Museum***

## **Status and Plans**

### **Current Status:**

- **ION VNM currently consists of:**
  - >50 entries approved and viewable (>1/2 are unique entries)
  - >20 entries in official review process
- **Review and validation of entries accomplished by Editorial Review Board**

### **Ongoing Developments and Plans:**

- **Continued refinement of submission and review process.**
- **Broaden area of specialization in Editorial Advisory Board by adding members.**
  - Have had to go outside of current review board for several entries.
- **Continue to work with GPS JPO/Wing on “Historical GPS Documents” and navigation related movies suitable for web site.**
- **Continue solicitation of entries, increasing breadth of entries, general awareness of ION VNM, exhibit booth at GNSS 2008**
- **Increase collaboration efforts with physical museums:**
  - USCG Historian
  - The Royal Observatory, Greenwich, England
  - The National Maritime Museum, Greenwich
  - The Oxford Science Museum, Oxford England
  - Other?? (The Aerospace Corporation, Northrop-Grumman, Boeing, etc.??)
- **Plan to establish and achieve a FOC metric.**



**ION VNM**  
**How to**  
**Submit an**  
**Item?**

The Institute of Navigation  
**Navigation Museum**

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 Do you have something that belongs in the ION Navigation Museum? Sharing your

# ***ION Virtual Navigation Museum FOC Plan***

## **How to Submit an Item?**

- **Is the item I have in mind suitable for the ION VNM?**
  - See ION VNM Policy & Procedures for scope and guidelines.
  - Talk to an ION VNM Editorial Advisory Board Member.
- **Submissions have come in the form of:**
  - Actual artifact that someone holds and is knowledgeable about it
  - Photograph, manual, drawings, etc and a knowledgeable person
  - Actual artifact in a physical museum (public, private, corporate)
  - Technical document of significance (e.g., Klobuchar model)
  - Working with an ION VNM Editorial Advisor Board member
- **Items not suitable for the ION VNM:**
  - Company products and services offered today
  - Common items of non-significance
- **Submissions via:**
  - Web form: [www.ion.org/museum/itemSubmission.cfm](http://www.ion.org/museum/itemSubmission.cfm)
  - Word Template: [www.ion.org/museum/VNM\\_Submission\\_Form.doc](http://www.ion.org/museum/VNM_Submission_Form.doc)  
then email to: [bartone@ohio.edu](mailto:bartone@ohio.edu)
- **Authorship provided for submitter.**

## ***ION Virtual Navigation Museum Editorial Advisory Board***

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## ***ION Virtual Navigation Museum*** **Invited Items**

- **Some key items have not been submitted to ION VNM:**
  - 621B
  - Decca
  - VOR/DME/TACAN
  - Early Draper's work
  - Fresnel Lens
  - GLONASS
  - Goldstone's Deep Space Network
  - Loran A & B
  - Omega
  - Sextant Varieties
  - Apollo Sextant
  - Early Sperry work
  - Timation
  - Transit
  - Y, Z, and T-set GPS Receivers
  - Other??? – LET US KNOW...

Ref: Bartone, C., "From Sextants to Digital GPS Receivers: The Virtual Navigation Museum Invites Submissions, ION Newsletter, Volume 18, Number 2, Summer 2008

# ***ION Virtual Navigation Museum***

## **Conclusions**

- **Development of the ION VNM illustrates the commitment by the ION not only to the advancement of the art and science of navigation, but also to the important task of preserving a record of the progress of navigation over the centuries**
- **ION VNM development continues**
- **Collaboration with physical museums have been beneficial and shown worthy to expand**
- **Some of the most unique and detailed entries have been from individuals with knowledge and insight into the navigation item.**
- **The ION VNM Editorial Advisory Board actively invites:**
  - **Submissions to Invited Items List**
  - **Additions to the Invited Items List**
  - **Volunteers for reviews and Editorial Advisory Board Membership**
  - **Volunteers for ION GNSS Booth help**
  - **Volunteers for entry solicitation and follow up.**
  - **Suggestions on physical museums for collaboration.**