NAVIGATION STABILIZATION ORIENTATION

Gyrolab LLC is a private Russian company.
Key focus areas:

1. INS — strapdown inertial navigation systems.

Development and manufacture of inertial navigation systems based on MEMS, fiber-optic and ring laser gyroscopes for navigation, stabilization, orientation for various purposes.

- **Aerospace applications and rocket technology:**
  - INS / gyrovertical / attitude and heading reference systems as part of aircraft navigation systems for manned and unmanned aerial vehicles (UAVs)
  - INS for spacecraft, including CubeSat
  - INS for rocket technology under conditions of increased shock and vibration effects

- **Ground / underground applications:**
  - navigation, stabilization and orientation of military equipment
  - unmanned vehicles and robotic devices
  - road and railway diagnostics
  - extractive industries:
    - directional logging survey / underground navigation during directional (horizontal and inclined) drilling
    - navigation and automation of an underground mining machine
    - systems for diagnostics and condition monitoring of vertical conductors in mines
    - in-line diagnostics (intelligent pig survey)

- **Marine / subsea applications:**
  - Shipboard INS and gyro compasses
  - As part of UUV (unmanned undersea vehicle) navigation systems
  - For unmanned navigation
  - For stabilization / roll-damping systems

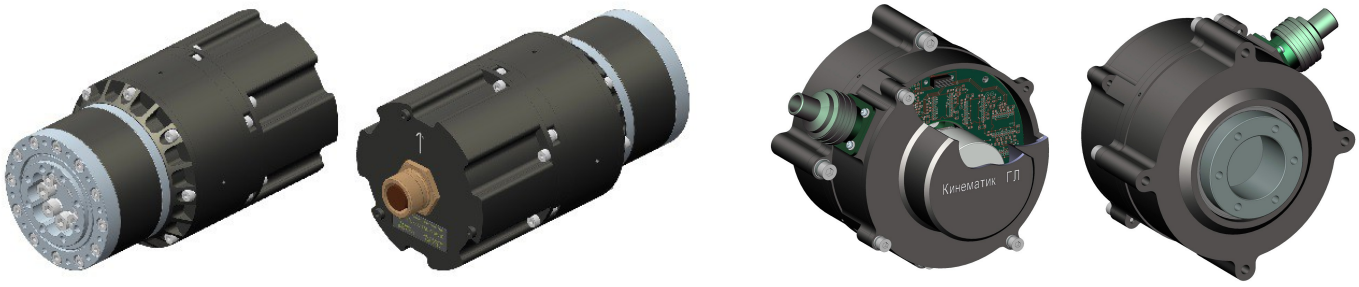
2. Gyro-stabilized platform, electric motors, drives

The development of gyro-stabilized platforms and suspensions (GSP) with a different number of axes according to the customer's TDA (Technical Design Assignment) requirements, as well as the serial production of already developed modifications are underway.

The GSP uses brushless direct drive motors, waveform gear drives, as well as linear drives, high-precision angle sensors (encoders) and rotating contacts.

GSP can be controlled using a spatial "proportional" control joystick with a built-in platformless microINS, which provides generation of control actions in the geographic coordinate system. GSP is a

set of ready-made units for building accurate attitude control, stabilization and control systems operating under conditions of external and internal disturbing influences.

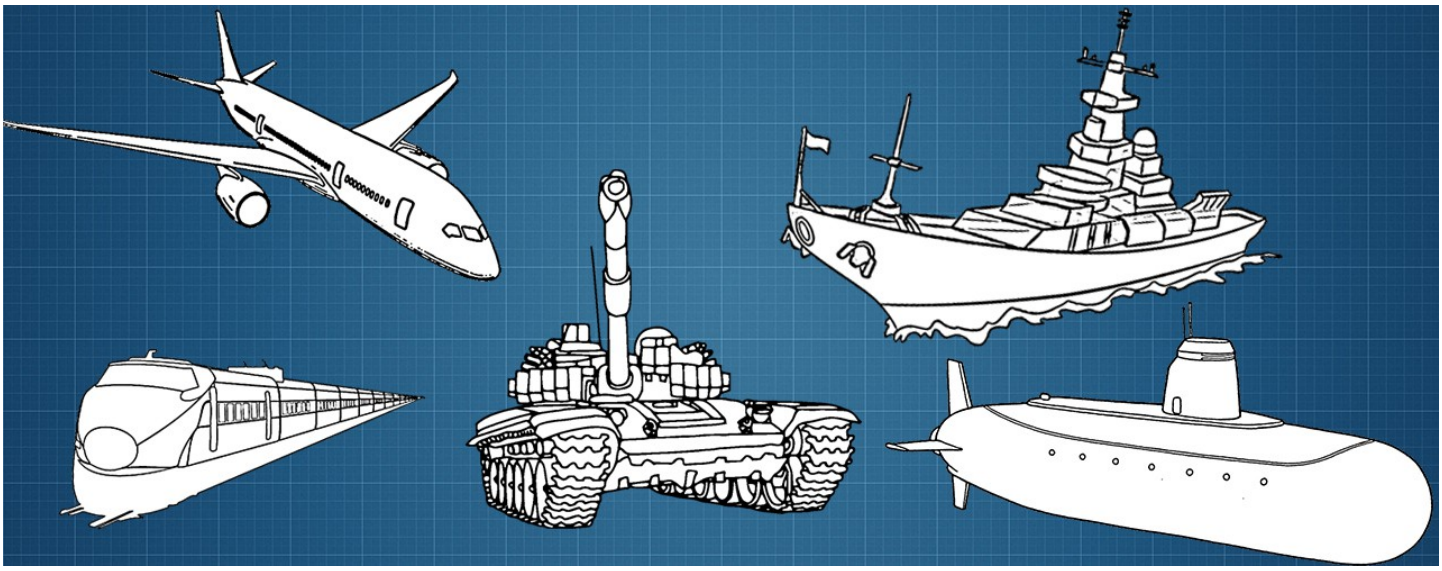


Over the years, the company has put into volume production more than 10 basic INS models, their numerous modifications, gyro-stabilized platforms for various purposes, and a large number of projects have been implemented for ground/underground, aviation, marine/subsea applications.

When supplying products, our company pays special attention to agreeing with the Customer the Technical Design Assignment (TDA), where all the parameters, that meet the requirements of the strapdown INS application conditions at a specific facility and for solving a specific range of tasks, are scrupulously prescribed. To meet the TDA requirements that go beyond the scope of serial products, we carry out the necessary improvements and modifications of design, circuit solutions, software and mathematical solutions.

"Gyrolab" strapdown inertial navigation systems have passed multiple tests, including tests on special equipment as well as shock and vibration tests with high overloads. Products are supplied to a wide range of customers both for civil and military applications.

We supply both finished packaged products and in the OEM version to enable partners to offer our developments under their own brand; our standard practice is to work under license agreements with handover of production documentation and manufacture localization; we can sell turnkey documentation for independent manufacture of products.



Gyrolab LLC has conformity certificate of the quality management system in relation to development, manufacture, sale, installation, mounting, repair and maintenance of weapons and military equipment.

Gyrolab LLC
www.gyrolab.ru ; inbox@gyrolab.ru
Moscow: +7 (495) 142 1137
Perm: +7 (342) 207 5398 / 97
Russia

Alexey Toropkov
Development Director
atoropkov@gyrolab.ru
Mobile phone / WhatsApp / Viber: +7 906 033 5779
Skype / Telegram: toropkov

MEMS Strapdown Inertial Navigation Systems (INS)

	GL-VG110-60 high precision	**GL-VG110-40 high precision**	**GL-VG110-20 high precision**	**GL-VG110**
Dimensions, mm	89 x 51 x 23	89 x 51 x 23	89 x 51 x 23	89 x 51 x 17
Weight, kg	0.12	0.12	0.12	0.12
Volume, l	0.1	0.1	0.1	0.08
Power, V (without galvanic decoupling)	27	27	27	27
Power consumption, W	1.6	1.6	1.6	1.5
Operating life (MTBF calculated), h	>15.000	>15.000	>15.000	>15.000
Technical characteristics, (1σ)				
Pitch and roll angle error:				
- on static position	0.02º	0.025º	0.03º	0.4º
- under any conditions	0.10º	0.19	0.50	1.0 subject to loss of correction for no more than 3 minutes
True Heading (Heading angle determination error)	1º/cos(φ) 0.5º/cos(φ) (typical) gyrocompassing mode	2.3º/cos(φ) 1.6º/cos(φ) (typical) gyrocompassing mode	7.6º/cos(φ) 2.7º/cos(φ) (typical) gyrocompassing mode	4º [3] not in gyrocompassing mode! determines only in motion with reliable GNSS data
Aligment Time (Gyrocompassing) (True Heading determination time)	5 minutes	5 minutes	5 minutes	-
True Heading holding error	0.25º/h	0.6º/h	2.0º/h	20º/h after performing the "drift correction" procedure
Coordinate error:				
- with reliable GNSS data (Hybrid Position)	According to the characteristics of the GNSS receiver	According to the characteristics of the GNSS receiver	According to the characteristics of the GNSS receiver	According to the characteristics of the GNSS receiver + 1 m
- with loss of reliable GNSS data (Inertial Position)	20 m / 3 min, 150 m / 6 min, 345 m / 8 min, 1040 m / 12 min, 9450 m / 30 min	75 m / 3 min, 410 m / 6 min, 850 m / 8 min, 2420 m / 12 min	140 m / 3 min, 920 m / 6 min, 2050 m / 8 min, 6400 m / 12 min	120 m / 1 min without taking into account the heading kinematic error
Velocity error with reliable GNSS data	0.15 m/s	0.15 m/s	0.2 m/s	0.3 m/s
Angular Rates measurement error	0.001 º/s or 0.2%	0.002 º/s or 0.2%	0.004 º/s or 0.2%	0.05 º/s or 0.3%
Acceleration measurement error	0.5 mg or 0.2%	0.5 mg or 0.2%	0.5 mg or 0.2%	0.5 mg or 0.2%
Limits:				
Angular Rates	±300º/c	±400º/c	±400º/c	±400º/c
Overloads	±20 g	±20 g	±20 g	±20 g
Additional features (embedded in the device):				
Barometric altitude, range	-0.5 ... 10 km	-0.5 ... 10 km	-0.5 ... 10 km	-0.5 ... 10 km
Magnetic heading	0.5º/cos(i)[1, 2]	0.5º/cos(i)[1, 2]	0.5º/cos(i)[1, 2]	0.5º/cos(i)[1, 2]
Magnetic induction measurement range	±400 μT ±200 μT (linear range)			

Notes: 1. In the absence of external magnetic disturbances; 2. i - Earth's magnetic field inclination in current coordinates
3. At: • moving velocity > 2 м/с • availability of reliable data from GNSS • GNSS coordinate error complies with the datasheet specifications (2.5 m, root-mean square error)

Basic models of Strapdown INS based on RLG (ring laser gyroscopes)

Parameters / Products	GL-120	GL-180.300	GL-300.301
Orientation/navigation parameters			
Error in initial determination of heading angle (σ), no more than, °	0.18/cos (latitude)	0.07/cos (latitude)	0.04/cos (latitude)
Error in holding heading angle in 1 hour of operation (σ), no more than, °	0.04	0.03	0.01
Error in determination of Roll, Pitch angles (σ), no more than, °	0.05 in all modes 0.015 in statics	0.03	0.02 (unmovable base: 0.01)
Error in computation of coordinates (σ) with adjustment from odometer / air data system / lag, no more than, % (of distance travelled)	0.5	0.25	0.2
Error in computation of altitude (σ) with adjustment from odometer / air data system / lag, no more than, % (of distance travelled)	0.25	0.2	0.15
Range: X/Y/Z, °/c	±600	±500	±500
Range of linear accelerations: X/Y/Z (g)	±10 (optional up to 30 g)		
Resistance to impact of external factors			
Temperature (working temp., stability), °C	–40...+55 (optional -60...+ 55)		
Temperature (limit temp., strength), °C	–55...+85 (optional -70...+ 85)		
Vibration (stability) (accidental 60 Hz–1KHz), g	5	5	5
Resistance to shock impacts (duration: 1 ms, form: ½ sine), g	100	100	100
Output data			
Functional readiness time (uptime), no more than, s	2	2	2
Accelerated gyro compassing time, no more than, s	360	360	360
Frequency of navigational decisions, Hz	1220Hz (0.8 ms)		
Electrical parameters			
Input/Output interfaces	Ethernet (100 Mbit), RS-485 2W/4W, RS-422, RS-232, discrete signals		
Supply voltage/Consumed power	18...32 V/< 20 W		
Mass and overall dimensions			
Overall dimensions (as part of shock absorber/without shock absorber) (L x W x H), mm, no more than		262 x 224 x 167	325 x 269 x 234
Weight (as part of shock absorber/without shock absorber), kg, no more than		9.5/optional	22.3/optional
MTBF (design)	15,000 hrs	15,000 hrs	15,000 hrs

Basic models of Strapdown INS based on FOG (optic fiber gyroscopes with closed loop)

Parameters / Products	GL-80	GL-90	GL-100	GL-150	GL-150/052
Orientation/navigation parameters					
Error in initial determination of heading angle (σ), no more than, °	0.4/cos (latitude)	0.2/cos (latitude)	0.12/cos (latitude)	0.08/cos (latitude)	0.05/cos (latitude)
Error in holding heading angle in 1 hour of operation (σ), no more than, °	0.15	0.06	0.05	0.04	0.04
Error in determination of Roll, Pitch angles (σ), no more than, °	0.1 (unmovable base: 0.02)	0.05	0.04	0.03	0.03
Error in computation of coordinates (σ) with adjustment from odometer/air data system/lag, no more than, % (of distance travelled)	1.5	0.6	0.4	0.25	0.2
Error in computation of altitude (σ) with adjustment from odometer/air data system/lag, no more than, % (of distance travelled)	0.4	0.3	0.3	0,2	0,2
Range: X/Y/Z, °/c	±550	±300	±250	±500	±500
Range of linear accelerations: X/Y/Z (g)	±10 (optional up to 30 g)				
Resistance to impact of external factors					
Temperature (working temp., stability), °C	−40...+55 (optional −55...+55)				−40...+55
Temperature (limit temp., strength), °C	−55...+85 (optional −60...+85)				−55...+85
Vibration (stability) (accidental 60 Hz–1KHz), g	5 (as part of shock absorber)				
Resistance to shock impacts (duration: 1 ms, form: ½ sine), g	100 (as part of shock absorber)				
Output data					
Functional readiness time (uptime), no more than, s	2	2	2	2	2
Accelerated gyro compassing time, no more than, s	360	360	360	360	360
Frequency of navigational decisions, Hz	610	610	610	610	610
Electrical parameters					
Input/Output interfaces	Ethernet (100 Mbit), RS-485 2W/4W, RS-422, RS-232, discrete signals				
Supply voltage/Consumed power	18...32 V/< 15 W	18...32 V/< 15 W	18...32 V/< 20 W	18...32 V/< 20 W	18...32 V/< 20 W (not considering consumption of rotating platform)
Mass and overall dimensions					
Overall dimensions (with shock absorber/without shock absorber) (L x W x H), mm, no more than	157 x 79 x 110 (fitting into a diameter of 119.8 mm)	207 x 231 x 162/ 120 x 166 x 107	207 x 231 x 162/ 166 x 154 x 155	300 x 293 x 186	Ø302x354
Weight (as part of shock absorber/without shock absorber), kg, no more than	–/1.33 kg	8.5/2.5÷5.1	9/3.7÷5.2	15/10.2	25
MTBF (design)	20,000 hrs	20,000 hrs	20,000 hrs	20,000 hrs	20,000 hrs