iNAT-RQT-4001 / -4002 / -4003

Inertial INS/GNSS/ODO/xxx Navigation and Surveying System

for Advanced Applications on Ground, at Sea and in the Air

iNAT-RQT-400x is a product family of high performance systems for inertial navigation and guidance, gyro compassing, pointing, stabilization, true heading determination and for dynamically motion analysis with most precise ring laser gyros, that covers applications, which require best of class accuracy, reliability, a flexible interface and easy usage.

- High performance ring laser gyro based inertial navigation and surveying system for airborne, naval, underwater, surface and railway applications; self gyro compassing. Additional dual-antenna GNSS heading setup as option (iNAT-RQT-400x-DA)
- Integrated time synchronization module and all-frequencies / all constellation GNSS / PPP / RTK engine with single or dual antenna. External atomic clock as option.
- High data rate, open interface: UART RS422 / RS232, Ethernet TCP/IP - UDP, CAN, ARINC429, ARINC825, NMEA 183.
- Integrated VMS / odometer / CAN interface.
- Internal 32 GByte non-volatile memory ("black-box"), up to 128 GByte on demand
- Small size, low weight, low power; integrated surveying markers and aiding support points on the enclosure (to support also advanced surveying applications).

The iNAT-RQT consists of three high precision ring laser gyroscopes, three servo accelerometers, a powerful strapdown processor and an open and modular architecture, which allows also adaptations to customer's demands.

The system contains an up to all-frequencies / all-constellations RTK / PPP capable GNSS receiver (GPS, GLONASS, GALILEO, Beidou), several Dig-I/Os (e.g. for odometer, laser altimeter, DVL), DAC. Optional communication I/Os are Ethernet (TCP/IP, UDP), RS422/232 UART, CAN, ARINC429, ARINC825 as well as internal data storage on non-volatile memory.

Data processing (strapdown navigation, gyro compassing or motion monitoring) is performed inside of the iNAT-RQT, and also data transmission and storage of pure or corrected raw data is available.

A key feature is its high data rate of up to 400 Hz and its unique resolution (0.001 degree in roll/pitch/yaw) as well as its superior accuracy (e.g., for stabilization tasks). As an option, special designed algorithms and features are available, e.g. the Multi-Vehicle-Tracking Mode (MVT), which allows an exchange of information between several iNAT systems without the need of any additional computation power. iNAT-RQT can also operate as NTP time server.

The iNAT-RQT contains iMAR's highly sophisticated 42+ state extended Kalman filter based INS/GNSS/ODO/xxx data fusion incl. gyrocompassing, free inertial or dead-reckoning navigation etc.

iNAT-RQT is usually operated in online mode, however, it also provides the possibility of post-processing, e.g. to perform additional reverse Kalman filtering and smoothing.

The systems iNAT-RQT are <u>not</u> ITAR controlled. The systems iNAT-RQT-4002 / -4003 are only covered by standard European dual-use export control. With iNAT-Rx/Fx/Mx several fit-function (FF) compatible systems are provided on RLG, FOG and MEMS technology. With iNAT-FSSG-1-DA a compatible system with dual-antenna GNSS technology is provided, which even does not require any export license. EU001 rules allow simplified export.




Technical Data of iNAT-RQT-4001 / -4002 / -4003 (rms values)

Data Output:	Heading, Roll, Pitch, Angular Velocity, Velocity (Body and World), Position, Raw Data of INS / GNSS / VMS incl. time-stamp, Internal Status Information
True Heading [1]:	iNAT-RQT-4001: 0.017° [0.3 mils] sec(lat) free inertial; < 0.01° with GNSS, < 0.006° post-proc RTK iNAT-RQT-4002A: 0.035° [0.6 mils] sec(lat) free inertial; < 0.01° with GNSS, < 0.008° post-proc RTK iNAT-RQT-4002: 0.057° [1.0 mils] sec(lat) free inertial; < 0.01° with GNSS, < 0.008° post-proc RTK iNAT-RQT-4003: 0.086° [1.5 mils] sec(lat) free inertial; < 0.01° with GNSS, < 0.008° post-proc RTK option: Dual-Antenna Setup with 0.2 °/L[m] with L = antenna baseline; e.g. 0.02 ° @ 10 m baseline (iNAT-RQT-400x-DA)
Attitude Accuracy [1]:	< 0.01° [0.18 mils] (< 0.005° with GNSS, < 0.0025° postproc with RTK aiding)
Position Accuracy [1]:	
iNAT-RQT-4001:	< 0.5 nm/hr free inertial [CEP][3]; typically < 1.6 m GPS (S/A off) and < 2 cm RTK online[1] < 0.01…0.08 % DT or 10 m [CEP50] (without VMS/odom., during 1 hr **GNSS denied environment** – for ground vehicles)
iNAT-RQT-4002:	< 1.0 nm/hr free inertial [CEP][3]; typically < 1.6 m GPS (S/A off) and < 2 cm RTK online[1] < 0.01…0.08 % DT or 10 m [CEP50] (without VMS/odom., during 1 hr **GNSS denied environment** – for ground vehicles) Example: road trial, 40 km traveling during 40 minutes, no VMS, no GNSS (GNSS denied): max. error 8.5 m in real-time
iNAT-RQT-4003:	< 1.5 nm/hr free inertial [CEP][3]; typically < 1.6 m GPS (S/A off) and < 2 cm RTK online[1] < 0.05…0.1 % distance travelled [CEP50] (with / w/o VMS/odometer aiding, during GNSS outages, application dependant)
all devices:	< 2 m [CEP50] with GNSS (under sufficient GNSS environment and visibility, S/A off)
all devices:	< 0.6 m with GNSS + SBAS (WAAS/EGNOS), < 0.1 m DGPS / Skylark and 2 cm RTK/INS (post-proc.)
all devices:	< 18 m horizontal [CEP50] / 10 m vertical [PE50] without GNSS and each 10 minutes ZUPT (given accuracy for up to 10 ZUPTs or 20 km distance)
all devices:	< 0.2 % distance travelled [CEP50] on underwater vehicles (with sufficient DVL/EM-log aiding)
Altitude Accuracy [1]:	< 5 m (under sufficient GNSS constellation and visibility, S/A off); 0.04 … 0.1 % DT [PE50] during GNSS outage < 5 % / 0.05 m heave (whichever is greater), typically < 2 % / 0.02 m (marine surface vessel applications)
Velocity Accuracy [1]:	< 20 mm/s for standard GNSS, 5 mm/s if aided with RTK GNSS, < 3 mm/s (postproc RTK)

Alignment Duration:

Class of System	Gyroscopes		Accelerometer		On-shore Alignment Duration to achieve true heading of (static): 0.25°	0.15°	0.10°	0.086°	0.06°	0.034	0.017° (sec lat)
iNAT-RQT-4001:	< 0.0016 °/√h	0.002 °/hr	< 12 µg/√Hz	50 µg |	2 min	2 min	2 min	3 min	5 min	7 min	10 min
iNAT-RQT-4002A:	< 0.0025 °/√h	0.005 °/hr	< 12 µg/√Hz	75 µg |	2 min	3 min	4 min	5 min	6 min	10 min	
iNAT-RQT-4002:	< 0.0028 °/√h	0.007 °/hr	< 12 µg/√Hz	75 µg |	2 min	3 min	4 min	5 min	6 min		
iNAT-RQT-4003:	< 0.0050 °/√h	0.010 °/hr	< 12 µg/√Hz	100 µg |	2 min	4 min	6 min	8 min			

Off-shore Alignment Duration = On-shore Alignment Duration + 15…60 minutes (depends on v-aiding)

Range:	± 395 °/s	± 20 g (option: ± 40 g)
Bias Stability (Allan Variance):	< 0.001 °/hr	< 12 µg
Resolution:	0.00033 ° (1,2")	< 5 µg (depends on data rate)
Scale/Linearity Error:	< 15 ppm / < 10 ppm	< 100 ppm / < 30 µg/g²
Axis Misalignment:	< 30 µrad	< 50 µrad

GNSS Receiver (integrated):	up to all frequency / all constellation GPS+GLONASS+GALILEO+BEIDOU, SBAS, RTK / PPP; high speed range version (< 515 m/s) available as option; L-Band as option; (iNAT-RQT-HRS, requires export license)
Input Interfaces (options):	external GNSS receiver (standard: integrated GNSS receiver); event trigger (PPS / SYNC, RS422 level), odometer (opto-coupler input up to 32 V, A/B quadrature or counts & direction, RS422 level compliant)
Output Interfaces (options):	UART RS232/422, Ethernet TCP/IP / UDP, CAN, ARINC429, ARINC825, HDLC/SDLC, PPT (Pulse Per Time), PPS, SYNC; NTP Server (since HW rev. 5); NTRIP caster; PPD (Pulse-per Distance)
Real Time Clock:	RTC Integrated as option; no internal battery required (no maintenance required)
Data Output Rate:	integer divisor of 400 Hz, internal data rate 3'200 Hz
Data Latency:	< 6.5 ms (sampling accuracy better 1 µs, time-stamped according to PPS; jitter < 1 ms)
Data storage:	128 GByte on internal non-volatile memory (option: 32 GByte)
RealTimeClock:	integrated RTC, maintenance-free (no battery required)
Dual-Antenna GNSS (opt.):	Additionally providing independent heading from dual-antenna GNSS setup: Accuracy = 0.2 deg/L[m] where L is the baseline between both antennas (example: 0.02 deg @ 10 m baseline)
Connectors:	MIL-C-38999 Series III for signals and power, TNC for antenna
Temperature (case), ingress protect.:	-40...+63°C operating, -55...+71°C storage; IP67; no degradation at temp. gradients (in contradiction to FOG based systems)
Magnetic insensitivity:	< 300 µTesla (3 Gauss); larger magnetic fields show lower impact than on comparable fiber optic gyros
MTBF / MTTR:	> 50'000 hrs iNAT-RQT, > 120'000 hrs ISA core (field tested) / < 30 minutes
Shock, Vibration, Altitude, rel. humid.:	6 g, 20 ms (operating); 50 g / 11 ms endurance; 5…2'000 Hz, 6.3 g rms (operating); 60'000 ft; 8...100%,
Qualification:	MIL-STD-810G, MIL-STD-461G, MIL-STD-704F; designed partially to meet DO160G
Power:	10...35 V DC, < 20 W (incl. GNSS); 50 ms hold up time according to DO160E; continuous overvoltage protection up to 60 V
Weight / Size:	approx. 6.9 kg / approx. 187 x 128 x 296 mm³ (w/o connectors);
Installation:	Installation in all arbitrary orientations allowed
Part-Number:	**00190-0420X-0Y0Z** (X = performance class, Y = GNSS engine, Z = single/dual-antenna GNSS)
Software:	internal real-time OS with INS/GNSS/ODO/xxx data fusion; real-time data output; iXCOM communication protocol; iXCOM-CMD GUI software under MS Windows and Linux available; Python / ROS-2 / C++ SDK for easy integration available; INS/GNSS post-proc iWP+ and iPosCAL available

iMAR Navigation GmbH manufactures and designs inertial navigation, surveying, guidance, control and stabilization systems for all applications. All systems are manufactured and maintained by iMAR Navigation in Europe / Germany.

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[1] values with GNSS or RTK (e.g. Skylark) aiding are given under the condition of sufficient GNSS availability and sufficient motion