

## GNSS &amp; POSITIONING INFRASTRUCTURE

# High-Precision GNSS, RTK & Reference Networks

Frequency-control and RF-filtering guidance for centimeter-class positioning, RTK base and rover systems, CORS / RTN reference networks and precision-machine applications.

**Multi-Band GNSS + RTK / PPP-RTK Corrections + Stable Receiver References + RF Selectivity**

RTK Base &amp; Rover

CORS / RTN

Surveying

Precision Agriculture

Machine Control

Infrastructure Monitoring

OEM GNSS

## Engineering Focus

Begin with the system node: multi-band GNSS RF front end, embedded RTK receiver, field correction radio, CORS reference server, external 5 / 10 MHz reference or always-on RTC domain.

## Architecture Consideration

Centimeter-level performance is created by the complete antenna, RF, receiver, carrier-phase, correction-link and estimation chain. Oscillator and SAW selections should follow the defined signal plan and error budget.

**1176.45  
MHz**

L5 / E5a lower-band anchor.

**1227.60  
MHz**

GPS / QZSS L2 anchor.

**1575.42  
MHz**

GPS L1 / Galileo E1 / BeiDou B1C.

**±50 ppb**

FCom high-stability TCXO class.

01

# Application Scope & System Architecture

**High-Precision GNSS, RTK & Reference Networks** covers systems that combine multi-frequency carrier-phase measurements with base-station, network or satellite-delivered corrections to support surveying, precision agriculture, machine guidance and long-term infrastructure monitoring.

## Representative Equipment

### Field RTK Equipment

- RTK base stations and rovers
- Survey and GIS receivers
- Precision-agriculture terminals
- Machine-guidance receivers

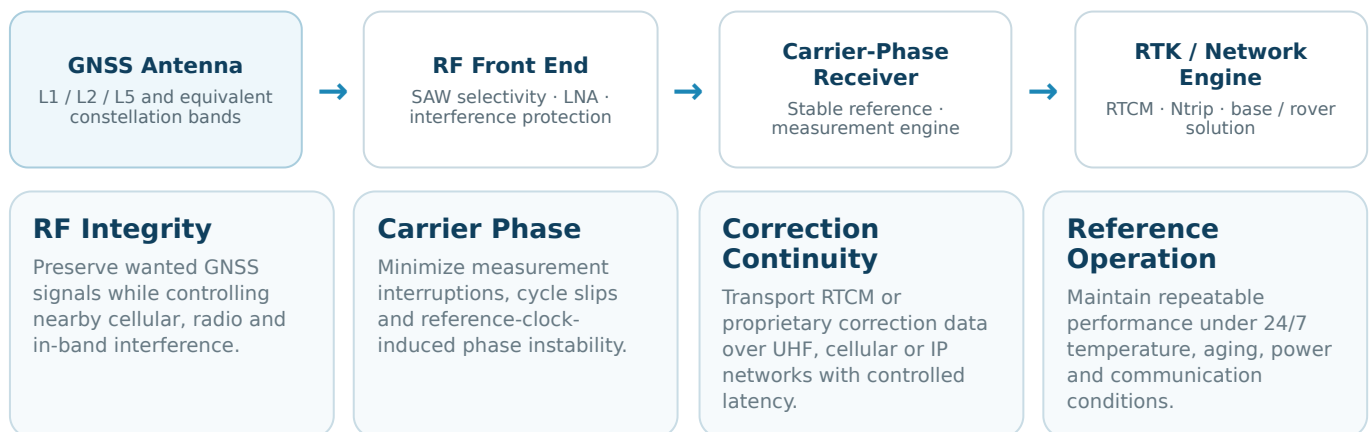
### Reference Infrastructure

- CORS reference receivers
- RTN / VRS reference networks
- Ntrip caster and correction gateways
- Geodetic data-logging stations

### Monitoring & OEM Systems

- Structural and deformation monitoring
- Atmospheric / seismic observation
- OEM carrier-phase receiver boards
- Embedded correction modems

## Representative High-Precision Positioning Chain



### FCom Solution Scope

FCom supports multi-band GNSS SAW filtering, compact TCXO references for embedded RTK receivers, high-stability TCXO solutions for reference infrastructure, sine-output OCXO solutions for defined 5 / 10 MHz external-reference inputs, and secondary crystal / RTC clock nodes.

### System-Level Performance

RTK convergence, fixed-solution availability and final position accuracy are equipment-level results. They depend on the antenna, RF path, multipath environment, constellation geometry, receiver algorithms, correction age, network latency and calibration as well as the frequency-control components.

02

## Select by System Node First

The same GNSS receiver can appear in a rover, field base or CORS station, but its RF, reference-clock, correction-link and environmental requirements change with the node.

### NODE 1 · MULTI-BAND RF FRONT END

#### GNSS Antenna, LNA & SAW Filtering

**Signals:** 1176.45, 1207.14, 1227.60, 1268.52, 1561.098 and 1575.42 MHz families.

**Define:** passband, insertion loss, group-delay behavior, rejection zones, antenna/LNA gain and coexistence environment.

**Selection direction:** evaluate frequency-specific GNSS SAW filtering after the required constellation set, combined-versus-discrete channel plan and rejection mask are defined.

### NODE 2 · EMBEDDED RTK RECEIVER

#### Local Measurement Reference

**Function:** provide the receiver or GNSS chipset with a stable local reference while controlling phase noise, temperature drift, power and package size.

**Common range:** 10–52 MHz; the exact value follows the selected GNSS receiver or RF chipset.

**Selection direction:** begin with a compact clipped-sine TCXO class; confirm exact frequency, supply, load, stability and phase-noise requirements from the receiver design.

### NODE 3 · CORS / RTN REFERENCE RECEIVER

#### 24/7 High-Stability Timebase

**Function:** support continuous carrier-phase observation, stable data products and repeatable network operation through thermal and aging changes.

**Define:** receiver input requirement, temperature profile, aging, reference switching, power-loss behavior and monitoring interval.

**Selection direction:** prioritize a wide-temperature, high-stability TCXO class when the receiver architecture exposes a replaceable local reference.

### NODE 4 · EXTERNAL FREQUENCY REFERENCE

#### 5 / 10 MHz Reference Input

**Function:** discipline an OEM or reference receiver from an external laboratory, station or system oscillator when the receiver explicitly provides this input.

**Define:** 5 versus 10 MHz, sine amplitude, 50  $\Omega$  loading, input error limit, warm-up, aging and phase-noise mask.

**Selection direction:** consider a sine-output OCXO only where the receiver publishes a compatible external-reference input and the complete interface can be matched.

### Correction Radio / Network Node

410–475 MHz or 902–928 MHz UHF paths, LTE and Ethernet are correction-transport domains. Select their RF filters and references independently from the GNSS measurement clock; exact channel plans and regulatory regions are required before assigning an ordering code.

### Always-On / Backup Domain

Where the design includes a discrete RTC or wake domain, specify the 32.768 kHz crystal by load capacitance, ESR, tolerance, drive level, start-up margin and operating temperature rather than treating it as part of the positioning accuracy chain.

03

# Frequency & Component Placement Matrix

GNSS carrier frequencies identify RF-filter locations. They are not the oscillator frequencies used by the receiver, processor or correction modem.

| Frequency / Signal                                                             | Common Placement                                               | Engineering Meaning                                            | FCom Selection Direction                                              | Qualification Note                                                     |
|--------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------|
| <b>32.768 kHz</b>                                                              | RTC / backup domain                                            | Calendar, wake and low-power timekeeping                       | Low-power tuning-fork crystal class                                   | Confirm CL, ESR, drive level and start-up margin                       |
| <b>5 / 10 MHz</b>                                                              | External reference input on selected OEM / reference receivers | High-stability station or laboratory frequency reference       | Sine-output OCXO class where the input is explicitly supported        | Match sine level, 50 Ω source/load and warm-up behavior                |
| <b>10-52 MHz</b>                                                               | GNSS receiver / RF chipset local reference                     | Measurement-engine clock; exact value is receiver-specific     | Compact or high-stability TCXO class, selected by node duty           | Confirm frequency, waveform, supply, load and phase-noise mask         |
| <b>1176.45 MHz</b><br>GPS / QZSS L5 · Galileo E5a · BeiDou B2a                 | Lower-band GNSS RF front end                                   | High-precision multi-frequency measurement band                | Compact 1176.45 MHz SAW selection path                                | Check required signal bandwidth and adjacent-service rejection         |
| <b>1207.14 MHz</b><br>Galileo E5b · BeiDou B2I / B2b                           | Lower-band GNSS RF front end                                   | Second high-precision multi-constellation band                 | Wide 1207.14 MHz SAW selection path                                   | Confirm whether E5 AltBOC or wider combined coverage is required       |
| <b>1227.60 MHz</b><br>GPS / QZSS L2                                            | L2 RF channel                                                  | Dual-frequency RTK and ionospheric-error estimation            | Signal-specific L2 SAW selection path                                 | Confirm wanted-signal bandwidth and group-delay requirement            |
| <b>1268.52 MHz</b><br>BeiDou B3I                                               | B3 RF channel                                                  | Additional carrier-phase observation band                      | 1268.52 MHz SAW selection path                                        | Confirm rejection mask and actual receiver channel bandwidth           |
| <b>1561.098 / 1575.42 MHz</b><br>BeiDou B1I / GPS L1 / Galileo E1 / BeiDou B1C | Upper GNSS RF front end                                        | Primary acquisition and multi-constellation measurement family | Wide upper-band SAW path for L1 / E1 / B1C                            | B1I or GLONASS-inclusive paths require a separately confirmed passband |
| <b>410-475 / 902-928 MHz</b>                                                   | Field correction radio                                         | RTCM / CMR correction transport—not a GNSS carrier band        | Custom FSF SAW selection after exact channel and bandwidth definition | Regional spectrum rules and coexistence drive the filter specification |
| <b>1 PPS</b>                                                                   | Receiver timing I/O and measurement alignment                  | Epoch marker; not a free-running oscillator frequency          | Use with the receiver timebase and calibrated I/O path                | Validate latency, pulse level, cable delay and reference-loss behavior |

**SAW Interpretation**

Center frequency alone is insufficient. Bandwidth, insertion loss, stopband zones, impedance and group-delay behavior should match the target RF design.

**Clock Interpretation**

The GNSS carrier band does not determine the TCXO frequency. The receiver or chipset hardware specification remains the authoritative source.

**FCom Portfolio Context**

The values shown here identify the applicable product class. Frequency-specific ordering codes and guaranteed limits are confirmed through FCom application review.

04

## Representative Platform & Architecture Matrix

Four public platforms illustrate how high-precision GNSS requirements change from an embedded RTK engine and field correction link to continuously operating reference-network infrastructure and externally referenced OEM integration.

### U-BLOX

#### EVK-F9P-01 / EVK-F9P-16 with ZED-F9P

01

EVK-F9P-01 evaluates the ZED-F9P L1 / L2 configuration; EVK-F9P-16 supports NEO-F9P or ZED-F9P L1 / L5. The platform provides built-in RTK for centimeter-level positioning and supports RTCM 3.3 or SPARTN 2.0 augmentation. u-center can operate as an NTRIP server / client for a two-kit base-and-rover setup, while MQTT can deliver PointPerfect PPP-RTK corrections.

Multi-Band  
GNSS

ZED-F9P RTK

RTCM / SPARTN  
Position

**Selection insight:** the ZED-F9P module integrates its own TCXO, RTC crystal and additional SAW. Within this architecture, FCom solutions are relevant to custom receiver implementations and the surrounding correction or host circuitry.

### TRIMBLE

#### R750 Model 2 Modular GNSS System

02

Field base / rover platform with published 8 mm horizontal / 15 mm vertical RTK precision, worldwide 4G LTE and integrated 1 W UHF. Model 218500-50 supports selectable 410–475 and 902–928 MHz operation; model 218500-40 supports 410–473 MHz. Public interfaces include RTCM 3.3 MSM, CMR / CMRx, NTRIP v1 / v2 client / server / caster and 1PPS.

GNSS  
Measurements

RTK Base

UHF / LTE /  
NTRIP

**Selection insight:** the GNSS reference and correction-radio reference are separate domains. A custom design may use GNSS SAW + TCXO at the measurement path and a separately specified TCXO / SAW pair at the licensed radio path.

### LEICA GEOSYSTEMS

#### GR50 / GR30 with RefWorx and Leica Spider

03

Reference-server architecture for permanent and semi-permanent 24/7 GNSS networks. The public platform uses a 555-channel engine supporting global and regional constellations. RefWorx provides RINEX logging, FTP, multiple RTK-client connections and Ntrip Caster / Server / Client operation; Leica Spider extends the node to Network RTK and monitoring services.

Geodetic  
Antenna

GR50 / GR30

Spider / Ntrip  
RTN

**Selection insight:** a 24/7 CORS node prioritizes multi-band RF selectivity, stable carrier-phase measurement, environmental stability and long-term reliability. Add an OCXO only when the target hardware explicitly provides an external-reference function.

### HEXAGON | NOVATEL

#### OEM729 Multi-Frequency GNSS Receiver

04

OEM board supporting multi-frequency GPS, GLONASS, Galileo, BeiDou, QZSS, NavIC and SBAS, with PPP, RTK, DGPS and SBAS modes plus Ethernet, USB, UART and RS-232 / RS-422. The external oscillator input accepts 5 or 10 MHz sine, 50  $\Omega$ , 0 to +13 dBm, with a published maximum reference-frequency error of  $\pm 0.5$  ppm. Ethernet supports NTRIP v2 client and server.

GNSS + 5 / 10  
MHz

OEM729 Engine

NTRIP / Position  
/ PPS

**Selection insight:** this platform provides a clearly defined external-reference insertion point. An OCXO candidate should be evaluated against the published sine level, 50  $\Omega$  interface, input-error allowance, warm-up and phase-noise requirements of the completed carrier-board design.

**Reference scope:** the platforms above illustrate publicly documented GNSS, correction-link and reference-clock architectures. They do not indicate that FCom components are used in or qualified for those products. Final selection is based on review of the customer's target schematic and electrical requirements.

05

## FCom Selection Guidance by Critical Function

The following four decision gates identify the FCom devices most relevant to clearly defined RF-filter and frequency-reference functions. Final configurations are confirmed against the target electrical, RF and environmental requirements.

### Decision 1 · Upper GNSS Band Selectivity FSF3030-1575M42-32M736-1.4-30

Representative FCom evaluation candidate for a wide multi-constellation L1 / E1 / B1C upper-band RF path.

**Package:** SMD3030

**Center / BW:** 1575.42 MHz / 32.736 MHz

**IL / Stopband:** 1.4 dB / 30 dB

**Confirm:** B1I / GLONASS coverage · rejection mask · impedance

### Decision 2 · Lower Multi-Band GNSS Front End

**FSF1109-1176M45-20M-1.4-40**

Compact evaluation candidate for L5 / E5a / B2a; separate paths may be applied where E5b / B2 and B3 are also required.

**L5 / E5a:** 1176.45 MHz · 20 MHz BW · 1.4 dB IL · 40 dB

**E5b / B2:** FSF3030-1207M14-40M-1.5-30

**BeiDou B3:** FSF3030-1268M52-20M46-0.6-30

**Confirm:** Combined versus discrete RF channels · group delay

### Decision 3 · Receiver Reference Stability FVT-3S or FVT-7S-WT

Determine the stability class from the receiver architecture and environmental requirement—not from the GNSS carrier frequency.

**Compact RTK:** FVT-3S · 3225 · 10–52 MHz ·  $\pm 0.5$  ppm

**Reference node:** FVT-7S-WT · 7050 · 10–52 MHz ·  $\pm 50$  ppb

**Temperature:** –40 to +85°C / –40 to +105°C respectively

**Confirm:** Exact frequency · waveform · supply · load · aging

### Decision 4 · External 5 / 10 MHz Reference

**FOC-2D**

OCXO evaluation candidate for an OEM or reference receiver with a compatible external sine-reference input.

**Frequency:** 5–40 MHz

**Stability:** To  $\pm 5$  ppb · –40 to +85°C

**Output:** Sine wave or HCMOS · 3.3 / 5 V

**Phase noise:** –115 / –135 / –145 / –150 dBc/Hz @10 / 100 / 1k / 10k

### Secondary RTC Node

For designs that include a discrete 32.768 kHz RTC crystal, the relevant inputs are load capacitance, ESR, drive level, start-up margin and operating temperature.

### Correction Radio Filter

FCom SAW solutions can support defined UHF correction channels. The final part number is assigned after the center frequency, occupied bandwidth, rejection mask and regional plan are confirmed.

### Final Configuration

The devices above are representative evaluation candidates. Frequency-specific electrical options and guaranteed performance are confirmed through FCom application review.

**RF-filter validation:** portfolio insertion-loss and stopband values provide an initial screening reference. Final validation should include S-parameters, rejection masks, antenna and LNA performance, matching, PCB loss and coexistence conditions.

06

## Primary Technical & Public Architecture References

Frequency, protocol and platform statements are based on official constellation, standards-community and manufacturer publications. FCom product specifications reflect the current portfolio information reviewed for this guide.

### GNSS SIGNAL DEFINITION

#### GPS Interface Control Documents

Official U.S. government access to IS-GPS-200 for L1 / L2 and IS-GPS-705 for L5 signal interfaces.

[gps.gov/interface-control-documents-icds-interface-specifications-iss](https://gps.gov/interface-control-documents-icds-interface-specifications-iss)

### GNSS SIGNAL DEFINITION

#### Galileo OS SIS ICD v2.1

Official Galileo Open Service signal characteristics, spreading codes and navigation-message structure for E1 and E5 families.

[gsc-europa.eu](https://gsc-europa.eu) · Galileo OS SIS ICD v2.1

### CORRECTION TRANSPORT

#### BKG Ntrip Reference

Public description of Ntrip Client, Server and Caster roles for streaming RTCM or other GNSS data over IP networks.

[igs.bkg.bund.de/ntrip/about](https://igs.bkg.bund.de/ntrip/about)

### GEODETIC DATA FORMAT

#### IGS RINEX 4.02

International GNSS Service publication index for the current Receiver Independent Exchange Format documentation used by reference infrastructure.

[files.igs.org/pub/data/format/](https://files.igs.org/pub/data/format/)

### EMBEDDED RTK PLATFORM

#### u-blox EVK-F9P / ZED-F9P

Official product information covering L1 / L2 and L1 / L5 variants, built-in RTK, RTCM 3.3 / SPARTN and NTRIP base / rover evaluation.

[u-blox.com/en/product/EVK-F9P](https://u-blox.com/en/product/EVK-F9P)

### FIELD BASE / ROVER PLATFORM

#### Trimble R750 Model 2

Official base / rover, RTK accuracy, GNSS signal, NTRIP, UHF correction-radio and 1PPS specifications.

[help.fieldsystems.trimble.com/r750/specs-r750.htm](https://help.fieldsystems.trimble.com/r750/specs-r750.htm)

### CORS / RTN PLATFORM

#### Leica GR50 / GR30

Official 24/7 reference-server, 555-channel, RefWorx, RINEX, Ntrip and Leica Spider Network RTK architecture.

[leica-geosystems.com](https://leica-geosystems.com) · GR50 / GR30

### OEM EXTERNAL REFERENCE

#### Hexagon | NovAtel OEM729

Official multi-frequency receiver, RTK / PPP, Ethernet / NTRIP and external 5 / 10 MHz sine-reference specifications.

[docs.novatel.com](https://docs.novatel.com) · OEM729 specifications

**Source and interpretation:** public sources establish the referenced architectures, interfaces and signal families. FCom selection guidance provides application-level engineering direction; reference to third-party equipment does not indicate that an FCom device is used in, qualified for or endorsed by that equipment manufacturer.

07

# Minimum Information for an Engineering RFQ

For an efficient engineering review, provide a separate requirement set for each RF filter, receiver reference, external frequency input and correction-radio clock rather than combining these functions into a single “GNSS oscillator” request.

## 1 • Equipment Node & Operating Mode

- RTK base, rover, CORS / RTN, monitoring station or OEM board
- Static, kinematic, machine-control or long-term monitoring mode
- Single base, VRS / Network RTK, PPP-RTK or post-processing workflow
- Normal, correction-loss, GNSS-degraded and power-recovery states

## 2 • GNSS Signal & RF Plan

- Required constellations and exact L1 / L2 / L5 / E5 / B1 / B2 / B3 signals
- Discrete-band or combined wideband front-end architecture
- Antenna type, LNA gain, cable loss, filter position and impedance
- Nearby LTE, UHF, satellite, jammer or other coexistence sources

## 3 • SAW Filter Requirements

- Center frequency and minimum passband—not only the band name
- Maximum insertion loss, ripple and group-delay requirement
- Stopband frequency zones and minimum attenuation for each zone
- Package, matching network, power level and operating temperature

## 4 • Oscillator Electrical Interface

- Exact frequency and fixed TCXO / VCTCXO / OCXO function
- Clipped sine, sine, CMOS or other required waveform
- Supply, load, source impedance, amplitude and enable behavior
- For external input: 5 or 10 MHz, 50  $\Omega$  level and connector path

## 5 • Stability & Noise Budget

- Initial tolerance, temperature stability and operating range
- Daily / yearly aging, warm-up, retrace and power cycling
- Phase-noise mask at specified offsets and measurement conditions
- Reference-loss duration, holdover expectation and calibration method

## 6 • Mechanical & Program Information

- Package, height, mounting, footprint and PCB constraints
- Prototype quantity, required sample date and validation stage
- Annual volume, lifetime, change-control and traceability needs
- Required reports, screening, qualification and compliance documents

### Receiver Validation

Check acquisition, carrier-phase continuity, cycle-slip rate, RTK convergence and fixed-solution availability over the full thermal profile.

### RF Validation

Measure insertion loss, return loss, out-of-band rejection, LNA compression and coexistence performance on the completed RF path.

### Network Validation

Verify RTCM content, Ntrip behavior, correction age, radio coverage, latency, failover and reference-station data continuity.

**Send one RFQ line per component function. FCom Engineering will identify the applicable series, ordering-code inputs and validation checkpoints. Technical Review →**

08

## High-Precision GNSS Engineering FAQ

### Why does RTK normally use more than one GNSS frequency?

Multiple carrier frequencies allow the receiver and correction engine to estimate ionospheric effects, improve ambiguity resolution and increase solution robustness. Final performance still depends on signal visibility, multipath and correction quality.

### Is 1575.42 MHz also the receiver oscillator frequency?

No. 1575.42 MHz identifies the L1 / E1 / B1C RF carrier family. The receiver's TCXO is normally a much lower device-specific reference such as a value within the 10-52 MHz range.

### Can one SAW filter cover every L1-family signal?

Only if its passband, insertion loss, group delay and rejection mask cover the complete required signal set. GPS L1 / Galileo E1 / BeiDou B1C may share an upper-band path, while BeiDou B1I and GLONASS L1 can require wider or separate coverage.

### When should a CORS receiver use an OCXO?

An OCXO is appropriate when the receiver exposes a compatible external-reference input and the system benefits from its stability, aging or phase-noise class. For a closed receiver architecture, continuous operation alone does not establish a requirement for an external OCXO.

### Does Ntrip define the receiver clock specification?

No. Ntrip transports GNSS correction data over IP. Receiver reference stability, correction age, network latency and radio-clock requirements are separate elements of the complete RTK error and availability budget.

### Does 1PPS replace a continuous frequency reference?

No. 1PPS is an epoch marker. The receiver still requires a continuous local frequency source for measurement timing and interpolation between pulses.

### Can a proposed FCom SAW device be selected from center frequency alone?

No. The passband, rejection zones, impedance, package, RF level, group delay and antenna/LNA architecture must be reviewed. The proposed devices are practical starting points for that review.

### Can an FCom component directly replace a part in a public platform?

The public platforms are used to illustrate system architecture. Any replacement requires confirmation of schematic function, frequency, waveform, level, package, pinout, RF response, qualification and equipment-level validation.

**Selection principle:** define the system node and electrical function first; then select frequency, RF bandwidth, stability, waveform, temperature and package. This avoids treating every clock or filter inside an RTK system as interchangeable.

09

## Convert the Architecture into a Qualified Selection

FCom Engineering reviews the complete RF and clock function before confirming a frequency-specific ordering code. The result is a concise, traceable recommendation aligned with the defined application requirements.

### 01 · Define the Node

Identify the RTK base, rover, CORS, monitoring, correction-radio or external-reference function and its operating modes.

### 02 · Lock the Signal Plan

Provide required constellations, GNSS bands, correction interface, oscillator frequency and electrical waveform.

### 03 · Apply the Budget

Allocate RF loss and rejection, clock stability, phase noise, temperature, aging, warm-up and correction continuity.

### 04 · Validate the System

Confirm the component in the completed RF path, clock tree and RTK workflow under representative environmental conditions.

### What to Send

- Block diagram or relevant schematic section
- GNSS constellation and frequency-band list
- SAW passband / stopband mask or clock electrical specification
- Temperature, stability, phase-noise and aging requirements
- Package, sample quantity, schedule and annual volume

### What FCom Returns

- Recommended product series and frequency-specific configuration
- Confirmed electrical, RF and environmental parameters
- Important matching, loading and validation considerations
- Sample / production feasibility and delivery discussion
- Technical documentation required for customer qualification

## Typical Review Outcomes

| Defined Function                   | Recommended Evaluation Class        | Information Required Before Confirmation                                           |
|------------------------------------|-------------------------------------|------------------------------------------------------------------------------------|
| Wide L1 / E1 / B1C RF path         | Wide upper-band GNSS SAW candidate  | Full wanted-signal bandwidth, rejection zones, impedance, antenna/LNA chain        |
| Compact embedded RTK reference     | Compact clipped-sine TCXO candidate | Exact frequency, supply, load, stability and phase-noise mask                      |
| Wide-temperature CORS reference    | High-stability TCXO candidate       | Exact frequency, waveform, stability budget, aging and environment                 |
| External 5 / 10 MHz sine reference | Sine-output OCXO candidate          | Sine level, 50 $\Omega$ interface, warm-up, phase-noise and mechanical constraints |

## Discuss Your High-Precision GNSS Architecture

Send the system node, GNSS bands, correction method, exact clock or filter requirement, temperature, package, qualification needs and project schedule. FCom will recommend the shortest technically relevant component path.

[General Inquiry](#)
[Technical Support](#)

**Product-data note:** the FCom specifications shown in this guide reflect current portfolio information reviewed on 21 August 2026. Frequency availability, final guaranteed limits and ordering codes are confirmed through application review and the applicable product documentation.