ICG Workshop on GNSS Interoperability

High Precision Applications

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Topcon Positioning Systems

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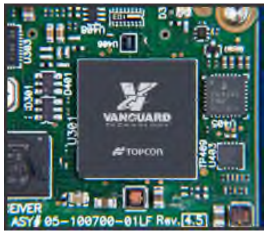
"Topcon Positioning Systems is in the business of development and manufacture of precision positioning equipment. The company offers a selection of innovative precision GNSS systems, commercial lasers, and optical instruments for surveying and civil engineering applications, machine control, the agricultural sector, and mobile data capture."

Full Spectrum GNSS Technology Provider



- In-house development of all core GNSS technology

- Multi-constellation ASIC development
  4th generation multi-core designs are currently in production

- Precision mobile and infrastructure antennas

- Full range of OEM and application-specific receivers that cover all GNSS frequencies

- Leading-edge tracking, navigation, fusion, and network algorithm development

Complete systems are delivered to a broad range of markets, using application-specific GNSS precision levels

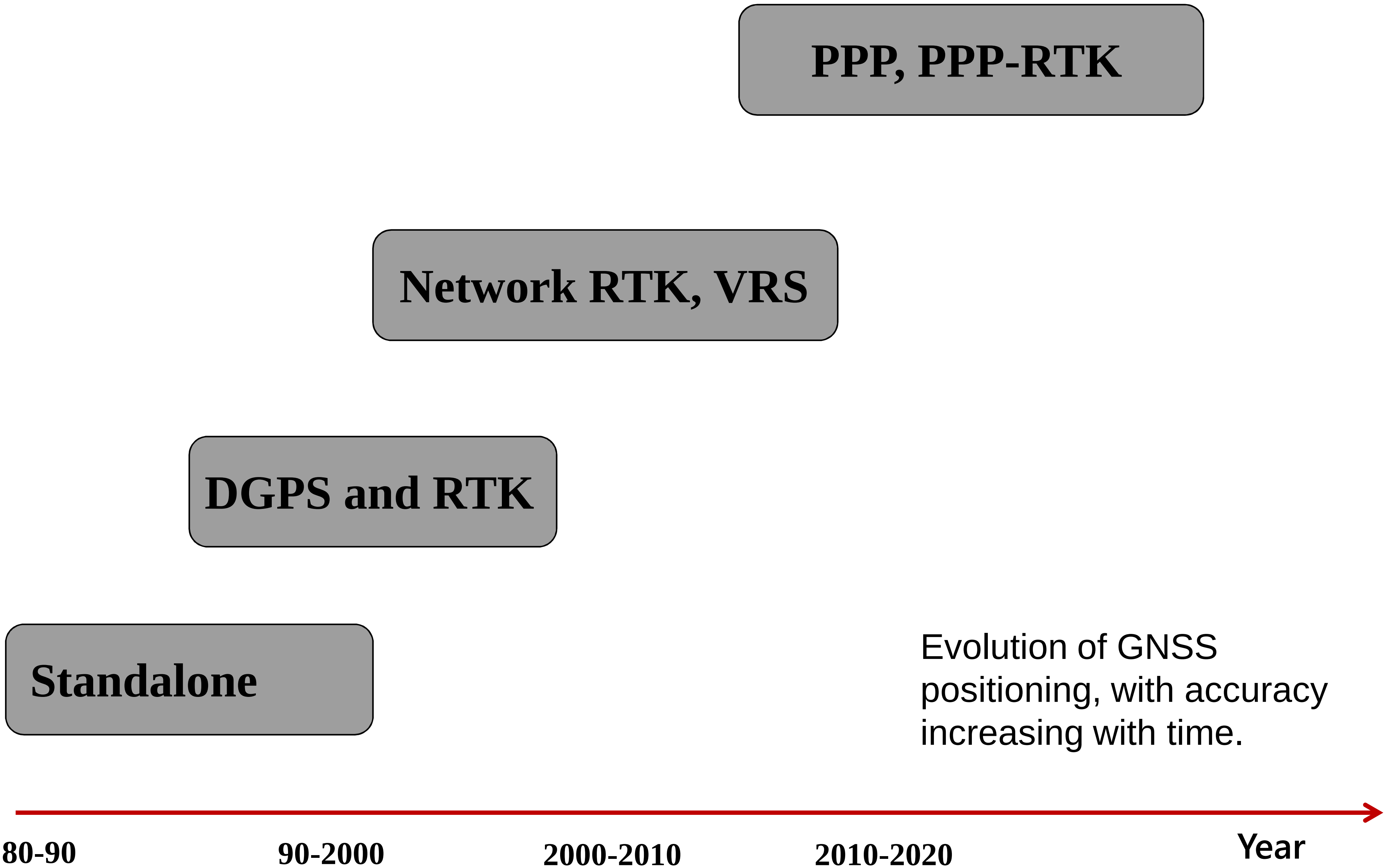
- High precision phase (<1cm)
- High precision code from terrestrial or wide-area corrections (<10cm)
- Medium precision code and phase (<50-80cm)

Precision Applications and Products: MACHINE CONTROL


TOPCON
AGI-3 Receiver
GX-45 Console
Auto Guidance
MAP
AUTO STEER
ASC

GNSS Interoperability and Compatibility

Topcon's view

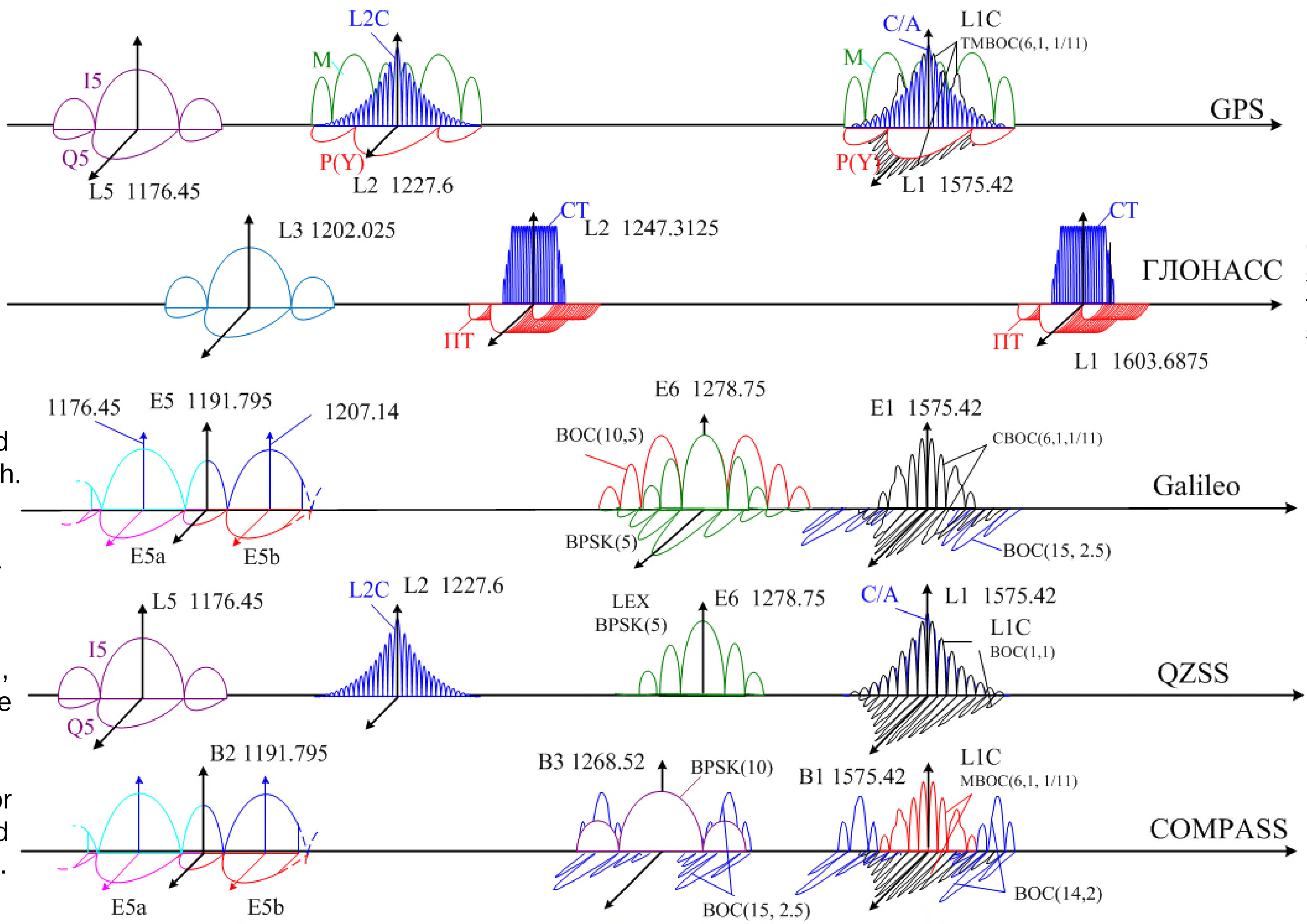


Evolution of GNSS positioning, with accuracy increasing with time.

GNSS Spectrum

What is of particular importance for Topcon, given the markets it serves, as new constellations and new signals are made operational?

New signals bring in increased bandwidth. Wider signals generally help to mitigate multipath, one of the primary limiting factors for increased precision.

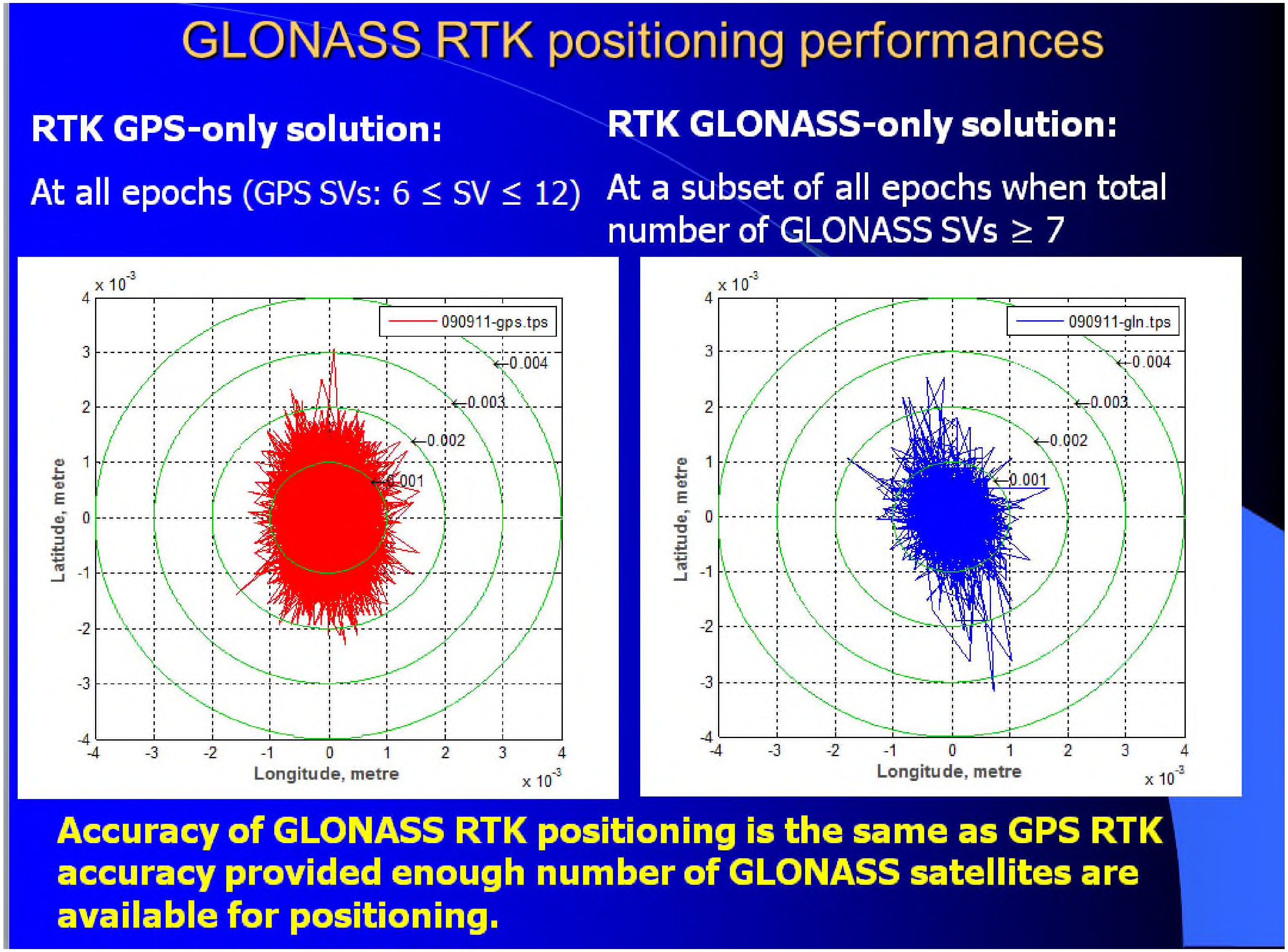


GLONASS signals without future CDMA signals

? Not clear frequency and spectrum long term plans

What is of particular importance for Topcon, given the markets it serves, as new constellations and new signals are made operational?

1. **ACCURACY of RTK solutions be the same for all constellations**



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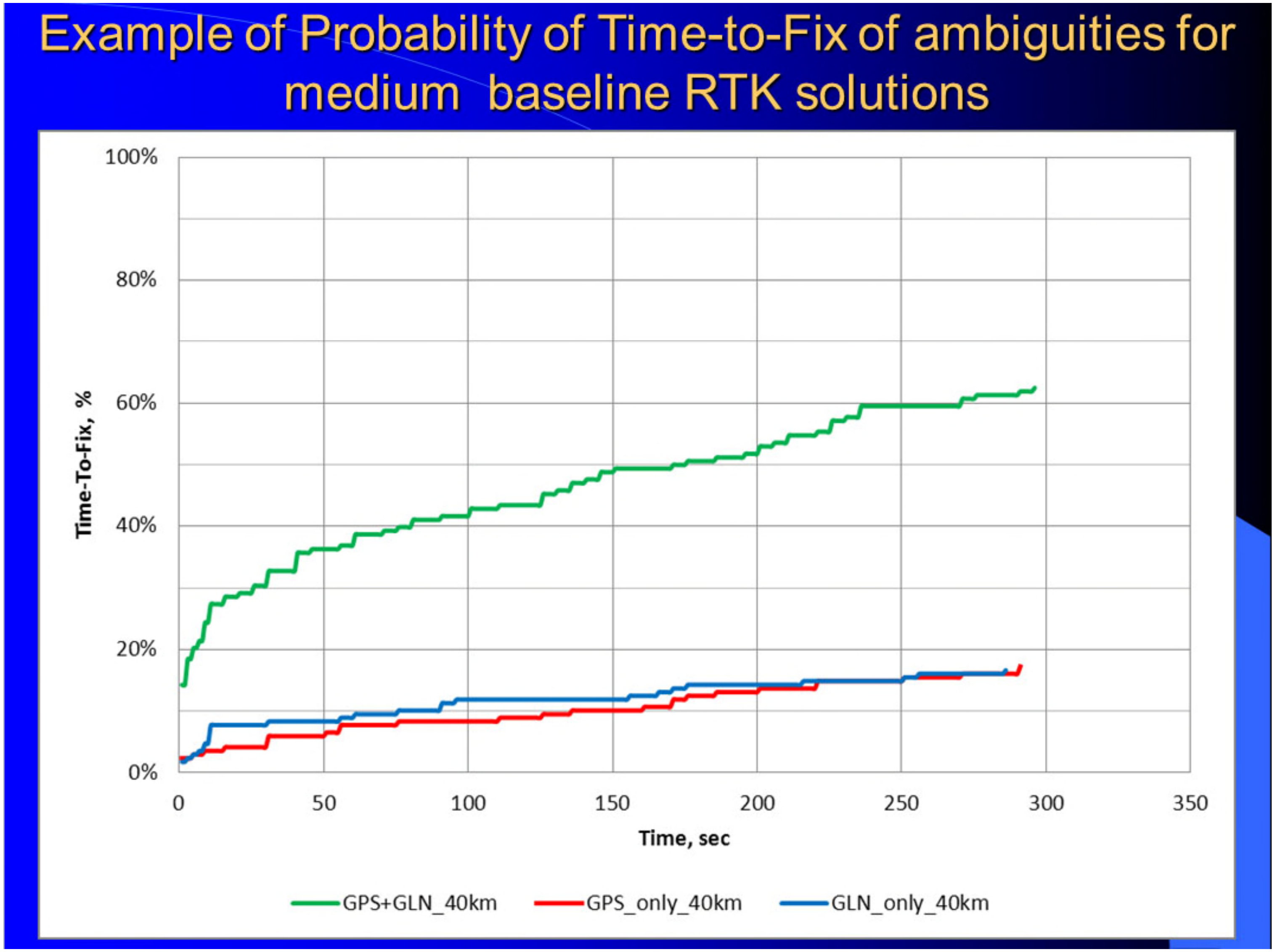
2. **TTF of ambiguities to continue to reduce**



There is no problem with bias/accuracy, GLONASS or GPS, so the same should be true for newer systems.

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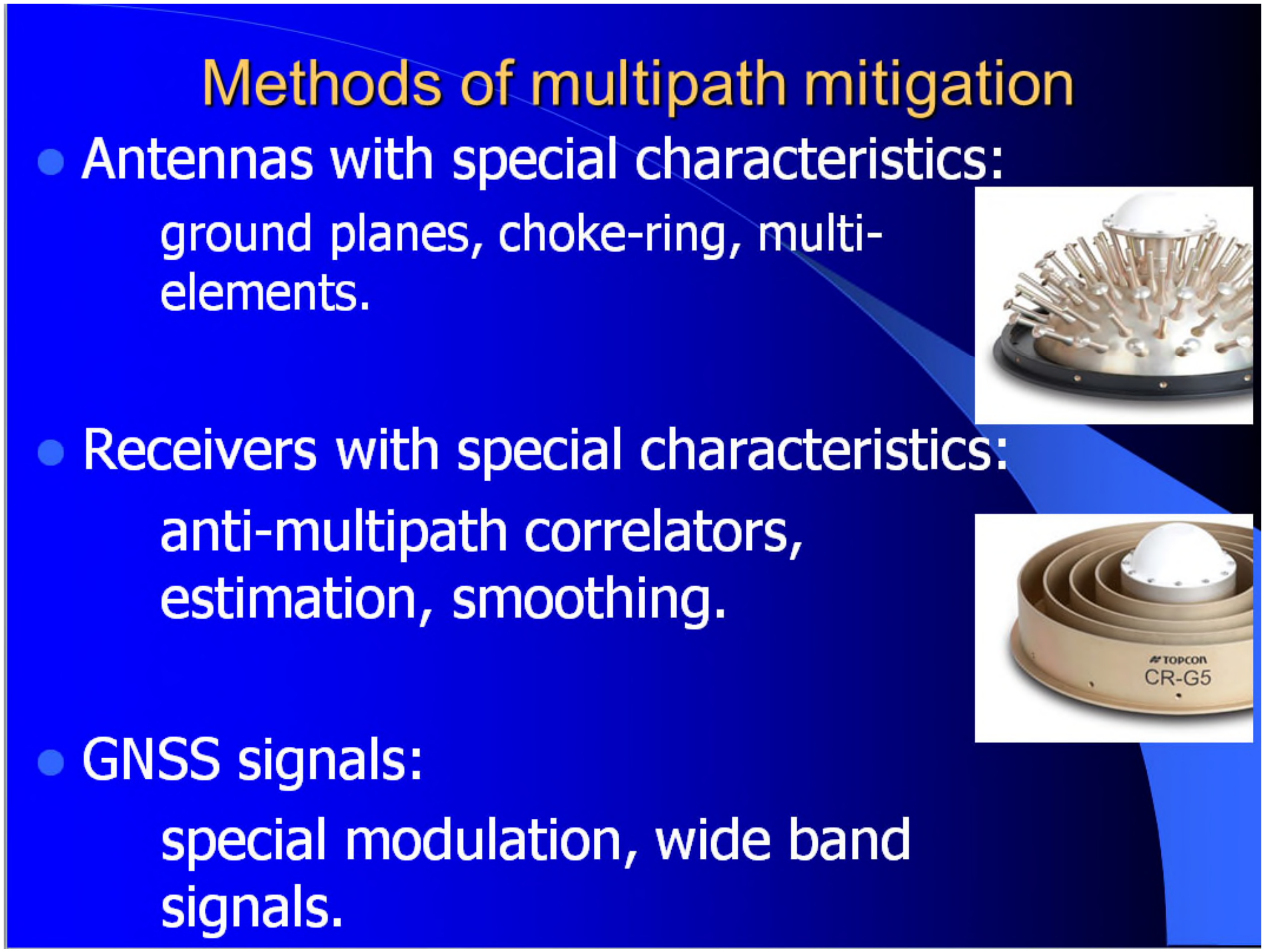
3. **Multipath Mitigation: Navigation Signals**



Navigation signals, if well structured, can reduce multipath error for all types of navigation service. The use of wideband signals (E5a + E5b) in GNSS frequency bands can significantly reduce the multipath error.

In essence: more signals create a better TTFF.

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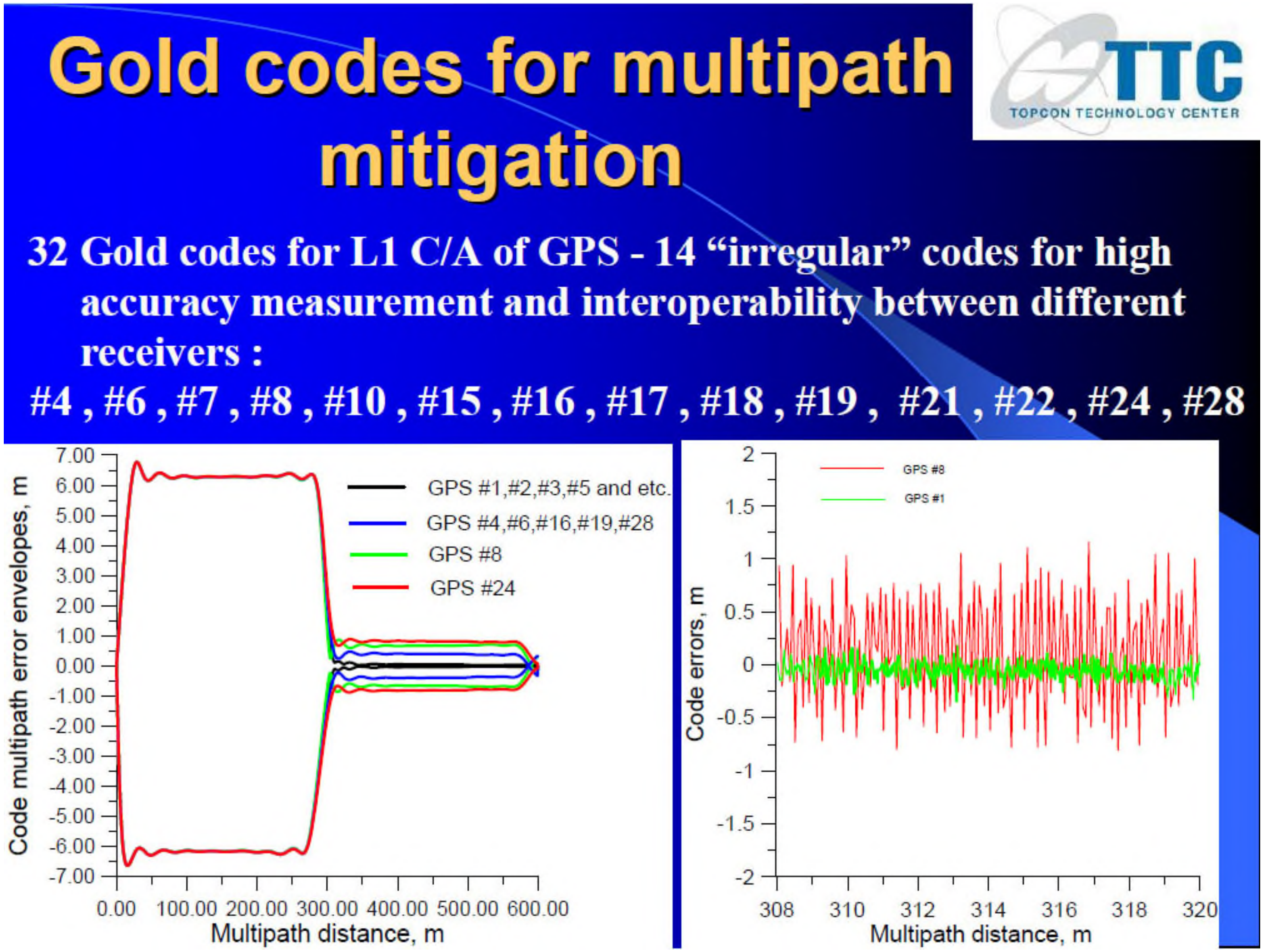
4. **Multipath Mitigation: Availability of Gold Codes**



145 new codes from #65 for #210 for different systems

48 ”irregular” codes: #65, #67, #73, #76, #78, ##81-83, ##92-95, #97, #100, #101, #107, ##112-114, #117, #119, #123, #124, #132, #137, ##147-149, ##167-175, ….

In essence: wider band signals and new codes, help to mitigate multipath.

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General Recommendations

- Free signal availability;
- Open access to signals and technical information;
- Timely availability of complete ICD documentation
- Improve multipath resistance;
- Improve jamming resistance;
- Improve cross correlation;
- Enhance presence of signals in different bands for improved TTF of RTK ambiguities
- Guarantee availability of signals with robust codes and modulation for different receiver technology;
- Deliver faster information about satellite health for all system
- The FDMA signals of GLONASS must be transmitted for support of old receivers.

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Specific Recommendations

Question	Answer
What types of applications do your receivers (or receiver designs) support?	High Precision Phase , High Precision Code, Medium Precision.
Do you see a threat to GNSS receivers due to many more GNSS signals centered at 1575.42 MHz?	Not any particular one.
Whether you see a threat or not, do you prefer all new CDMA signals at “L1” to be centered at 1575.42 MHz or have some of them elsewhere, e.g., at 1602 MHz?	For critical high precision application is the best way to have signals in different band for noise immunity, but for low cost application is very interesting to have common signal in one L1 band.
Given that most GNSS providers plan to transmit a “modernized” signal at 1575.42 MHz, what is your long term perspective on whether you will continue to use C/A? Why? How?	Some of our receivers are working in many places from 1998 and they can't receive the "modernized" signals. The new generation can of course. But time life of receiver is around 10 years. Possible, after 10 years we may do without C/A.
Once there are a large number of good CDMA signals, will there be continuing commercial interest in FDMA signals? Why or Why Not?	Will be. In old generation of receiver we used and can't change that now. Possibly, in 10 years we may avoid use of FDMA
Do you prefer signals in different “L1” frequency bands for interference mitigation rather than at one center frequency for interoperability? Why?	Interesting to have one common siglal for low cost receivers (AG market) and in different freq. band for good noise immunity
If a satellite’s signals do not meet quality standards, what should happen (see list in slide)?	For example the provider shall mark this in the almanach. But the quality signals is reviewed in receivers and for different application there are different catchers

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Specific Recommendations

Question	Answer
To assure only “good” signals, should GNSS providers agree on minimum international signal quality standards and agree to provide only signals meeting the standard?	The problems is to prepare the standard on signals. The catchers in receivers help us understand good or not so good signals
Given that L5/E5a will be transmitted by most GNSS providers, do you intend to use the E5b signal? If so, for what purpose?	The E5a+E5b is a wide band signal and have small multipath. It will be interesting for high precision application (RTK, PPP) for minimize time-to-fix.
For your applications, are small satellite “frequency steps” a problem?	no problem.
If so, what interval between “frequency steps” and what delta-f magnitude would be excessive?	N.A.
Assuming signal quality is acceptable from every provider, would you limit the number of signals used by provider or by other criteria? What criteria?	We suggest to have 3 freq. bands and Data and Pilot signals.
Is having more signals inherently better or do you think there should be a limit?	3 freq. band and some signals (Data and Pilot).
Will the marketplace “force” you to make use of every available signal?	Not clear yet.
For best interoperability, how important is a common center frequency? How important is a common signal spectrum (PSD)?	A Common center freq. signal spectrum are not dramatically impotant. The common freq. band approach is very interesting to us.
Will you provide “tri-lane” capability in the future? Why?	Yes. For time-to-fix RTK and PPP purposes.

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Specific Recommendations

Question	Answer
If so, do you prefer a common middle frequency or the combined use of L2 (1227.6), B3 (1268.52), and E6 (1278.75) if B3 and E6 open access is available	We plan to use - 3 freq. GPS (L1,L2,L5), 3 freq. GLONASS (L1,L2,L3), 3 freq. GALILEO (E1,E5,E6 (not open ICD now)). Interesting to have 3 freq. with open signals from COMPASS.
Would you prefer a common open signal in S Band? In C Band? Why?	Needs investigation. But may be there will be more accuracy for C band.
Does a wider satellite transmitter bandwidth help with multipath mitigation?	Yes, it will help.
What minimum transmitter bandwidth would you recommend for future GNSS signals in order to achieve optimum code precision measurements?	It is a compromise for different signals. In some band not wide band, in some wide band. The Alt-BOC signal is a very interesting example.
Would you recommend GNSS or SBAS services provide interoperability parameters (see list in slide)?	Yes
Should they be provided by other means so as not to compromise TTFF or other navigation capabilities?	Not clear yet.
For your applications and for each signal, what amount of drift between code and carrier over what time frame would be excessive?	This topic needs further investigation.
For your applications and for two or more signals in different frequency bands, e.g., L1 and L5 (when scaled properly), what amount of relative drift in code and carrier between the signals would be excessive?	This topic needs further investigation.
Should the international community strive to protect all GNSS signal bands from terrestrial signal interference?	Yes, the noise protection of GNSS band we consider very very important.

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Specific Recommendations

Question	Answer
Do the current differences (~10 cm) in Geodesy pose a problem for your users? Why or why not?	Not really, Different GNSS coordinate systems have a matrix of transformation between systems.
If geodesy differences are a problem, what is the preferred method of compensation (see list on slide)?	This topic needs further investigation.
Do you want each system to cross reference the other's time (e.g., with a GGTO type of message) or compare itself to a common international GNSS ensemble time? To what precision?	For standalone applications we can use the cross reference time. The precision is of the same very accuracy of the standalone mode.
Will your future receivers calculate a time offset between systems based on signal measurements or use only external time offset data?	For high precision GNSS it will be calculated in the receivers, for Standalone we can use the external time offset data.
What is the preferred method of receiving time offsets: Satellite messages, Internet messages, or internally calculated?	For high precision we believe in internally calculated offsets, while for standalone can be used satellite messages.

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