第11回測位技術懇話会
中央電気倶楽部（大阪・堂島）
2019年2月1日

PPPの定義について

Precise Point Positioning

測位技術振興会
一般財団法人 衛星測位利用推進センター

PPPの始まり – 1997～2002年

1997 : **Zumberge** et al. “Precise Point Positioning for the Efficient and Robust Analysis for Large Networks,” J. Geophys. Res., 102, pp.5005-17

2002 : **Yang Gao**, Xiaobing Shen, “A New Method for Carrier-Phase Based Precise Point Positioning,” Navigation: Journal of ION

- PPP は、GNSSコミュニティの関心が高くなってきた新技術
- 基準点の観測情報へのアクセスを必要とする伝統的なディファレンシャル測位と異なる
- ただ一つの受信機で測位できるので、使いやすく、コストの点で優れる。
- 搬送波位相観測を用いてデシメータ級やセンチメータ級を狙うので、従来測位と異なる
- リアルタイムのデシメータ級、センチメータ級精度の測位と航法が近い将来可能になる
- 波数不確定を解決する手順を実装すると、リアルタイム・キネマティック（RTK）PPPが可能となるであろう。 *・・・2002年の洞察は、今日実現している・・・*

Precise point positioning (PPP) is a new positioning technology that has received increased interest from the GPS community. Different from the traditional differential positioning technique, which requires access to observations from one or more reference stations with known coordinates, PPP involves only a single receiver; therefore, it is easy to deploy and cost-effective. PPP is also different from the conventional point positioning technique since it aims for decimeter- to centimeter-level positioning accuracy using carrier-phase observations. ・・・・・ *PPP for real-time decimeter- to centimeter-level positioning and navigation accuracy will become possible in the near future.* ・・・ If the initial phase value in the receiver and satellite oscillators can be minimized to a negligible level in the future, *it will be possible to implement an ambiguity resolution procedure to fix the ambiguity parameters to their true integer values for real-time kinematic PPP processing of centimeter level accuracy.*

米国航法学会 ION : Institute Of Navigation

2017 - 2019

2005 18th ION ITM at Long Beach

PPP-RTK: Precise Point Positioning Using State-Space Representation in RTK Networks

Gerhard Wübbena, Martin Schmitz, Andreas Bagge,

Session : LOW-COST HIGH PRECISION GNSS POSITIONING

New algorithms and methods to support high precision applications using low-cost GNSS receivers and systems. New research results to address fundamental and essential issues unique to low-cost GNSS positioning and mass-market applications, such as signal processing techniques for quality carrier phase measurements, bias identification and mitigation, new corrections and service strategies, new user positioning models and algorithms, multi-GNSS systems (GPS, GLONASS, Galileo, BeiDou), quality control algorithms, fast convergence and ambiguity resolution with global **PPP** and **PPP-RTK** in wide areas. New algorithms and methods for integration of GNSS positioning with other low-cost navigation sensors, to enhance the availability and robustness of low-cost high precision GNSS systems in challenging environments.

Co-chairs: **Dr. Yang Gao**, *University of Calgary*, Dr. Junesol Song, *ENAC, France*

・・・Gao先生は本年も議長を務める・・・

国際規格RTCM標準の規定 – 2013年制定

RTCMで補強情報の国際標準化を2007～2012に議論・検討、現在もWGが続く

海事無線技術委員会（本部：ワシントンDC近郊）が制定
RTCM : Radio Technical Committee for Maritime Services
RTCM標準10403.2　3.5.12.2節
RTCM標準10403.3　3.5.13.2節（内容は10403.2と同じ）
精密単独測位（PPP）で用いるSSRメッセージを規定

PPP ＝ Precise Point Positioning　精密単独測位
SSR ＝ State Space Representation 状態空間表現

補正データ	verb	PPPの種類
Precise orbit, Satellite clock, Satellite code bias	enable	Dual Frequency Real-Time PPP **DF-RT-PPP（二周波PPP）**
次項目を加える: Vertical TEC (VTEC)	enable	Single Frequency Real-Time PPP **SF-RT-PPP（一周波PPP）**
次項目を加える: Slant TEC (STEC), Troposphere, satellite phase bias	enable	Real-Time Kinematic PPP **RTK-PPP（RTK単独測位）**

※ みちびき仕様書 IS-QZSS-L6-001（CLAS）が参照している国際デファクト標準

国際規格RTCM標準 – 原文

Radio Technical Committee for Maritime Services, RTCM STANDARD 10403.2, Differential GNSS(Glabal Navigation Satellite Systems) Services – Version 3, RTCM Special Committee No.104, February 1, 2013, RTCM Paper 104-2013-SC104-STD.

Radio Technical Committee for Maritime Services, RTCM STANDARD 10403.3, Differential GNSS(Glabal Navigation Satellite Systems) Services – Version 3, RTCM Special Committee No.104, October 7, 2016, RTCM Paper 141-2016-SC104-STD.

10403.3

3.5.13.2 State Space – SSR Messages

The SSR Messages are developed in three major steps:

1. The development of messages for precise orbits, satellite clocks and satellite code biases.
   This is compatible to the basic PPP mode using IGS products. Such messages will enable real-time PPP for dual frequency receivers: DF-RT-PPP.
2. The development of vertical TEC (VTEC) messages.
   This will enable RT-PPP for single frequency receivers: SF-RT-PPP.
3. The development of slant TEC (STEC) messages, tropospheric messages and satellite phase biases messages.
   This will enable RTK-PPP.

The current SSR message types cover the first stage of DF-RT-PPP.

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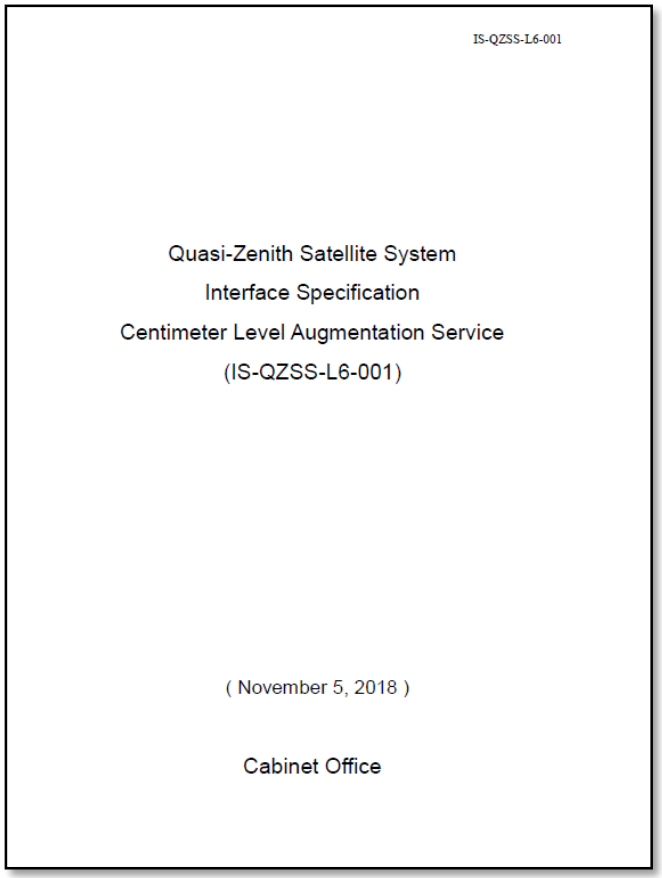
「みちびき」CLAS 仕様書



IS-QZSS-L6-001

Quasi-Zenith Satellite System

Interface Specification

Centimeter Level Augmentation Service

(IS-QZSS-L6-001)

(November 5, 2018)

Cabinet Office

4.1.2.2 Data Part

The data part of the L6 message includes any sub type of multiple messages of MT 4073 “Compact SSR,” as defined in the applicable document (3). The data in each message is given in state space representation (SSR) form, as standardized in the applicable document (2) RTCM STANDARD 10403.2. The correction in SSR form can be applied to **precise point positioning - real-time kinematic (PPP-RTK).**

改定履歴

April 3,2018	2	Updates applicable document (3) Replaces reference document (8) with an updated one. Adds reference document (9)
	3-4	Adds contents of section 2.3 and 2.4
	20	Adds description to clarify the meaning of nominal validity period in 4.1.1.2 (4)
	23	Changes the PPP-RTK form RTK-PPP
	22, 69	Corrects description of subframe indicator in Table 4.1.2-2 and 4.2.2-2
	24	Adds description for user algorithm in 4.1.2.2.1
	28	Updates Compact SSR signal mask in Table 4.1.2-9

※ 日本の仕様書は律儀に国際動向を反映している

ISO 18197:2015 センチメータ級測位のサービス要件

English

International Organization for Standardization

When the world agrees

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Store › Standards catalogue Browse by ICS 49 › 49.140 › ISO 18197:2015

ISO 18197:2015

Preview

Space systems -- Space based services requirements for centimetre class positioning

ISO 18197:2015 defines the requirements for the wide area centimetre class positioning system by broadcasting augmentation data through satellites as follows.

- Centimetre class positioning

According to the progress of requirements for positioning services such as automatic farming, mapping and others, centimetre class positioning is very useful.

- Wide area positioning

Buy this standard

	Format	Language
✔	PDF	Englis
	Paper	Englis

CHF 138 Buy

National PPP and Global PPP

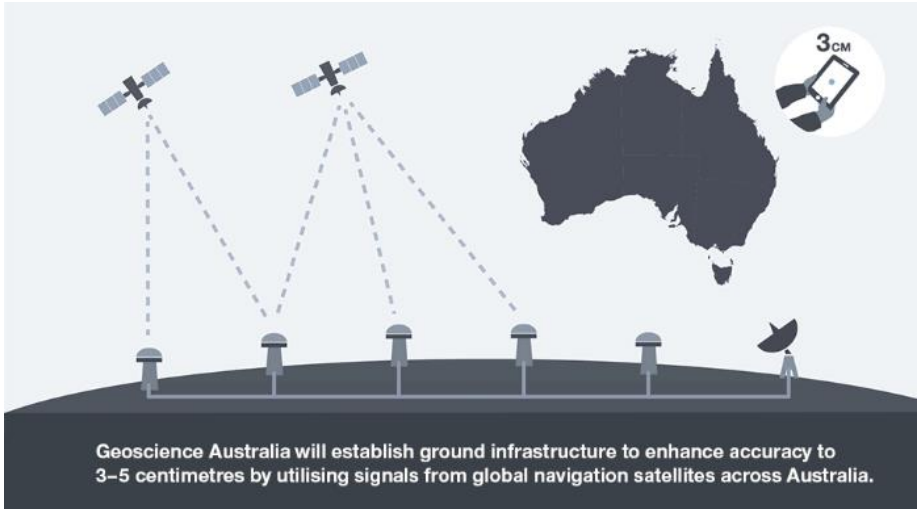
複数の国に National な PPP がある。

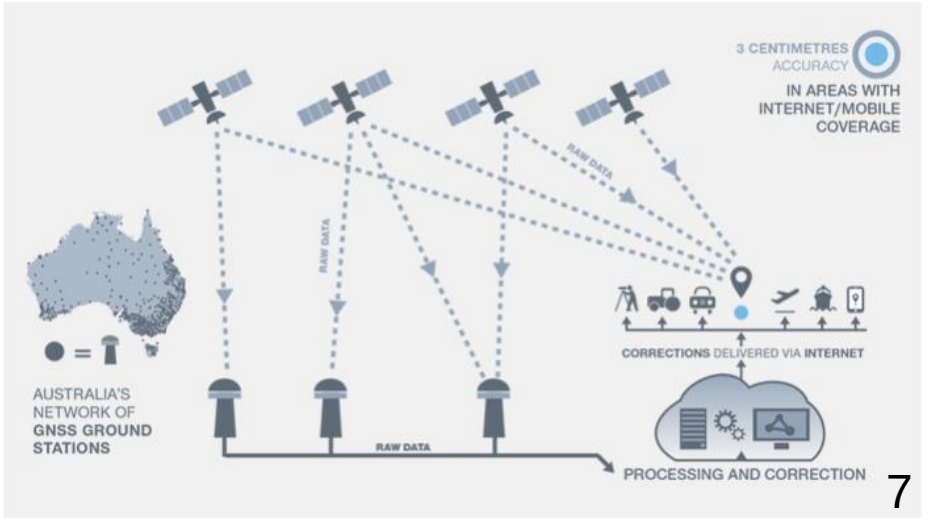
カナダ

CSRS-PPP
Canadian Spatial Reference System

オーストラリア, ニュージーランド

SBAS & PPP





まとめ

- 国際標準と世界の動向を踏まえた
  準天頂衛星仕様書に準拠しましょう。

- 国内企業は協力し、世界市場をめざしましょう。
  - 日本市場は世界の6%（←池の中）

※ 学会・業界団体で協調、市場で競争
（競合同士が仲良くとは言わないが、足は引っ張らないこと。日本産業としてはマイナス効果のため）

補遺：Draft standard of definitions (modest idea)

positioning
determining position

point positioning
single receiver positioning not using observables from any other receiver

PPP
precise point positioning
point positioning to augment precision

PPP-AR
PPP with ambiguity resolution

PPP-RTK
PPP with ambiguity resolution using external atmospheric correction

atmospheric correction
correction for atmospheric errors including ionospheric diffusion or tropospheric delay

RTK
real-time kinematic (GNSS positioning)
kinematic positioning using carrier-phase measurement in real-time