measurements, thereby generating directly an alternative System Time Scale taking the benefits from Atomic Clocks and Pulsar Clocks simultaneously.

An eGPC Interface Control Document (ICD), Guidelines for Integration and a Developer Manual will be made available to allow SW Configuration Items or Equipment to be connected and integrated in the eGPC.

The results of the demonstration shall provide guidance for planning future activities, ranging from introduction in future PNT systems, to recommendations for tools updates and design methodologies updates.

Funding required: €400k	*Duration:* 18 months	*ITT issue:* 4Q 2017

4.3.2. Cooperative navigation and cloud processing

The current evolution of the Internet of Things (IoT) and Smart Cities, together with the proliferation in the last years of cloud platforms where storage and processing of data can, ideally, be handled on demand, has boosted the appearance of new applications and services in the positioning domain of potential interest for specific use cases.

In particular, the processing in the cloud of GNSS signal snapshots can be of interest when targeting a gain in terms of power consumption or computational burden, offloading the local device or chipset from the full GNSS processing. Moreover, cloud processing allows the application of complex or advanced positioning or navigation solutions that require a high computational burden, or depend on the usage of heavy assistance information (e.g. radio and magnetic fingerprinting maps, detailed 3D maps, etc.). And, of course, new positioning applications or processing techniques can be derived from, or take advantage of, the crowd-sourced and/or cooperative processing of the GNSS signal snapshots and other sensor data gathered by the low-end devices connected to the Internet. Some of the potential applications and techniques based on the concepts of cooperative navigation and cloud processing have undergone preliminary studies. Nevertheless, the maturity of the topic is relatively low, with few applications covered so far, and multiple techniques and applications of high potential interest, still to be studied and assess in detail.

Following on from previous studies on Peer-to-Peer which have been performed in the ESA TRP program, the proposed activity shall study and develop new innovative positioning and navigation techniques relying on the exploitation of crowd-sourced data and GNSS signal snapshots from low-end sensors or devices connected to the Internet, enabled by high-data-rate and low-latency wireless communication networks, and based on the cooperative and cloud-processing of the data.

The tasks to be performed will include:

- study, design and performance assessment of snapshot-based and cooperative cloud-processing of GNSS signals based on signal snapshots grabbed with low-end devices and other crowd-sourced data of interest for different use cases;

- studying potential crowd-sourced data and/or signals of potential interest to be exploited for the improvement of the positioning solution (e.g., in terms of sensitivity, robustness, accuracy) or of interest to generate assistance information to be exploited later in the cloud, like fingerprinting maps (of any type);

- study and design a flexible architecture for a concept demonstrator based on the exploitation in the cloud of the signal snapshots and data gathered by a network of sensors or devices, based on existing wireless communications infrastructures and commercial cloud processing platforms;

- implementation and preliminary demonstration of the proposed techniques and cloud architectures, and quantification of the benefits provided for different use cases of interest;

- mapping of technological solutions/enablers and use cases, and derivation of conclusions and recommendations for future activities.

The results of the study will provide guidance for planning future activities including further studies, testing and proof of concept activities possibly integrated with follow-on tests from other activities

Provisions will be taken so that results and/or test equipment can also be made available for follow-on R&D activities of EC/GSA.

Funding required: €400k	*Duration:* 12 months	*ITT issue:* 3Q 2017

4.3.3. Weather monitoring based on collaborative crowdsourcing

The use of GNSS observations from reference stations for the derivation of Integrated Water Vapour and assimilated into Numerical Weather Prediction Models has been demonstrated and is in use for weather prediction. With the emergence of multi-constellation and multi-frequency GNSS the possibilities of weather prediction with GNSS are increasing dramatically.

Furthermore, with the emergence of powerful handheld GNSS receivers, with multi-frequency capability and access to both code and carrier-phase observables, the possibility of GNSS weather monitoring with collaborative crowdsourcing is emerging as a very promising field.

This activity, therefore, is needed in order to assess the use of GNSS carrier-phase and multi-sensor localisation in smartphones and similar devices for monitoring extreme

weather and supporting weather forecasting. Furthermore, the development and testing of a complete end-to-end demonstrator of this innovative concept is hereby proposed to prove the concept.

Some of the innovation aspects proposed are the following:

- use of low-quality sensors (namely fitted in handheld devices) but in a very large number, allowing a very large sample of observations and spatial resolution accuracy;

- maximising the exploitation of GNSS data for weather forecasting, in particular the use of code and carrier-phase observables (future chipsets will provide these new observables for multi-constellation, driven by the Android version providing those), and preferably dual-frequency (new feature for handheld receivers), in particular for the derivation of integrated water vapour (IWV) measurements for assimilation in weather prediction models (this requires a high-precision processing approach). The use of this observable has not yet been exploited because they were not available until very recently.

The tasks to be performed will include:

- a thorough assessment of all existing GNSS technologies and GNSS data processing in support of this proposed weather monitoring (e.g. determining water vapour content);
- understanding of the potential of other weather-sensitive sensors built in to mobile phones (existing or that could be integrated);
- assessing the exploitation of mobile weather sensitive geo-location and collaborative crowdsourcing for weather monitoring and forecasting;
- an end-to-end representative demonstrator.

A natural follow-on to this activity could include the setting up of an operational version of the proposed weather monitoring service and its actual commercialisation.

It is to be noted that this proposed activity was identified and supported by ESA's GNSS Science Advisory Committee (GSAC), notably during the dedicated GNSS Science Workshop held at ESAC in July 2016, which was held to support ESA in the identification of future areas of interest in the scientific field of GNSS.

Funding required: €300k	*Duration:* 12 months	*ITT issue:* 3Q 2017

4.3.4. Space GNSS receiver for in-orbit demonstration of Precise Point Positioning (PPP)

The current approach for precise orbit determination (POD) with GNSS is based on the collection of code and carrier phase measurements from space GNSS receivers and computation of precise orbit with ground post-processing tools. This approach is