## DRAFT

## Report of the Central America Tsunami Advisory Centre (CATAC)

N**otes**
1)The CATAC Users guide (updated version 2023) can be downloaded from <http://catac.ineter.gob.ni/doc/CATAC%20Guia%20de%20usuario%20SPANISH%2020190710.pdf>

A completely new version of the Users Guide will be elaborated in 2023 in a common initiative of all TSP´s of the ICG/PTWS to standardize to some extent the content of these guides among all centers.

2) A short history of CATAC (version 2023) is given below as an annex of the present report.

3) The progress of CATAC was presented and discussed in the last 2 years in several meetings of the UNESCO system for tsunami warning, within the steering committees of PTWS, CARIBE EWS, and in the yearly meetings of TOWS.

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**Background Info**

After a series of discussions in the region on the improvement of the tsunami warning system and several meetings in the ICG/PTWS-WG-CA (2009, 2011, 2014) the government of Nicaragua the creation of CATAC at INETER/Managua was officially 2015 by. Previously two missions sent by JICA/Japan had investigated the conditions in the region for the improvement of the tsunami related disaster reduction and prevention. The final result of their work was that in Nicaragua existed the best situation for the establishment of a Tsunami Service provider (TSP) for The Central American Region. The proposal was supported by a meeting of the relevant seismological agencies in the region and by the civil protection agencies represented by CEPREDENAC which sent a supporting letter sent to the IOC). In 2015, the proposal was presented by Nicaragua at the meetings of ICG/PTWS, ICG/CARIBE-EWS and the IOC Assembly and was accepted by these three relevant organizations.

From 2016-2019 the CATAC reinforcement project was carried out with support from Japan with the following products: SeisComP PRO software with TOAST, workstation with high speed Graphical Processor able to run the easy wave software which permit tsunami simulation in real time, 8 new broad band seismic stations in Nicaragua, support for the completition of 8 sea level stations in Nicaragua (INETER had already acquired the sensors) , virtual seismic network with 600 stations, intense capacitation in Japan and Nicaragua on capacitation in Nicaragua and Japan, master studies in Japan ( ATAC has now 7 masters on seismology and tsunami). In the same time frame UNESCO projects were carried out for Tsunami mitigation in Central American countries (on SOP, Tsunami Ready) and in 2016 a project on the development of Earthquake Early Warning (EEW) was started at INETER in cooperation with ETHZ/Switzerland.

In 2019, ICG/PTWS and ICG/CARIBE-EWS accepted the experimental operation of CATAC. In 2021 ICG/PTWS accepted CATAC to start full operation. However, approval of CATAC as an official TSP still needs to be confirmed by ICG/CARIBE-EWS which is requested in the present session.

ICG/PTWS-XXIX already decided in December 2021 to admit the start of CATAC's full functionality as of 17 January 2022 for the Pacific coast of Central America.

In this session, CATAC is requesting to ICG/CARIBE-EWS XVI to also admit CATACs full operation for the Caribbean coast of Central America.

**Current situation of CATAC**

CATAC relies on 400 seismic stations in Central America and 200 global seismic stations via Incorporated Research Institutions for Seismology (IRIS). There are 24/7 two watchstanders working in a shift system, from a group of 16 watchstanders. Seismological processing is conducted with SeisComP PRO. Tsunami evaluation is done with a database and using SeisComP TOAST for real-time simulation. CATAC sends an initial alert message within two minutes of an earthquake. A tsunami parameter message is disseminated less than 10 minutes after the earthquake. These messages are addressed to 11 monitoring/scientific institutions, PTWC, (NTWCs in preparation), nine civil protection agencies and one regional coordinating body (Centro de Coordinacion para la Prevencion de los Desastres en America Central y Republica Dominica, CEPREDENAC).

The CATAC Areas of Service are Pacific and Caribbean coasts of Central America. The monitoring area in the Pacific Ocean is delimited by a polygon starting at Mazunte along the coast of Southern Mexico, the coasts of Central America, Colombia and Ecuador until Manta/Ecuador continuing with the polygon in the ocean from Mexico - Galapagos Island to Mazunte/Southern Mexico. The monitoring area in the Caribbean Sea is defined by the Caribbean coasts of Central America, the coast of Belize, Yucatan (México) and then with a polygon from

The cooperation with Central American scientific bodies, including the Instituto Nicaraguense de Estudios Territoriales (INETER); the Ministry of Environment and Natural Resources (MARN) of El Salvador) and the General Directorate of the Environmental Observatory (MARN-DGOA); Instituto de Sismología, Vulcanología, Meteorología e Hidrología de Guatemala (INSIVUMEH); the Honduras Comisión Permanente de Emergencias (COPECO) and the Universidad Nacional Autónoma de Honduras (UNAH); the Sistema Nacional de Monitoreo de Tsunamis (SINAMOT) and the Observatorio Vulcanológico y Sismológico de Costa Rica (OVSICORI) from the Universidad Nacional de Costa Rica (UNA); the Red Sismológica Nacional (RSN) of the University of Costa Rica (UCR); and the Panama Institute of Geosciences of the University of Panama (IGC-UPA), Panama Canal, and Red simica Baru (Ángel Rodríguez). A very close relation exists with MARN/El Salvador and discussions are underway with them to be a possible back-up centre for CATAC.

CATAC has certainly a good relationship with civil protection agencies in Central America, it is still less strong than with the scientific bodies. The civil protection agencies in Central America receive products from CATAC and cooperate with CATAC in the monitoring of earthquakes and tsunamis as well as information and capacitation. Nonetheless, CATAC is striving to improve its relationship with these agencies including through closer cooperation with CEPREDENAC.

Between 2021 and 2022 The project EWARNICA/ATTAC with ETHZ/Switzerland expanded the network of seismic stations in Nicaragua, El Salvador, Costa Rica and Guatemala. New accelerographs 25 new accelerographs were installed in Nicaragua, 25 in El Salvador, 17 in Guatemala, and four in Costa Rica. This enables the reduction of the time needed for detecting and locating earthquakes, improved quality of results, the ability to calculate very fast Moment Tensor (and magnitude) of strong earthquakes with local stations (not saturated) and enable the creation of Shakemaps and seismic impact recording in major installations.

There exist good relationship that exists between CATAC and Central American seismic network operators, which facilitates access to real-time data. In the beginning, CATAC was only receiving data directly from these institutions, which sometimes proved challenging when faced with Internet difficulties, as this would mean data could not be received readily. As such, CATAC is currently looking for alternative means of data. Central America is endowed with a dense network of stations which provides an opportunity for strengthening CATAC’s capacity. Indeed, there are more than 1100 stations in Central America, around 400 of these currently transmitting to CATAC. CATAC thanks UNAM México, Colombian Geological Service, Instituto Geofísico Ecuador to provide data from their networks directly (about 20 stations each). Other data are obtained via IRIS from seismic stations in the Caribbean.

The distribution of seismic stations in and around Central America used by CATAC is sufficient for Nicaragua, El Salvador, Guatemala, and Costa Rica. But it presents deficiencies for Honduras where the network collapsed due to impacts from the COVID-19 pandemic. CATAC has offered Honduras support for the reconstruction of its network. In Panama, the Canal administration provides data from its complete network around the waterway and near the cities of Panama and Colon; also Red Sismica Baru, a private initiative in the Western part of the country, provides data. CATAC would expect Panama´s NTWC at University of Panama to provide data from its large seismic network. Considering the elongated geography of this country and the distribution of its seismicity a more equally distributed network of stations is necessary for the rapid and reliable processing of local tsunamis. Some improvements have been achieved for the networks in Honduras, Panama since the last ICG/CARIBE-EWS Meeting.

This large number of local stations in Central America could be used in future using the Finite-Fault Rupture Detector (FinDer) algorithm (Böse et al., 2012) which is able to provide a reliable estimate of magnitude and rupture parameters in real time obtaining a final results a short time. CATAC is in the moment testing this method and pretends to implement it in routine work in the near future.

There exists a lack of sea level stations in Central America, with many stations currently offline This is due to the high environmental risk at the coast (e.g. ships passing, storms and waves), the prioritization of seismic stations over sea-level stations, and the expensive nature of installing, maintaining, and repairing sea-level stations. It is therefore a priority for CATAC to continue engaging with institutions to facilitate sharing of data from their sea level stations network and to install new stations. CATAC proposed to identify potential additional institutions from the region which could install and maintain sea level stations, including for example from the Panama Canal.

CATAC proposes to use the new facilities offered by STARLINK (<https://www.starlink.com/>) relatively cheap satellite based internet with very low delay and high reliability to improve the Internet connection between CATAC and the NTWC´s and sensors in remote areas, as for instance islands.

CATAC’s fulfills the capacity requirements of TSPs. With regards to the requirement for dissemination of tsunami forecast information freely and in a timely manner to NTWCs/tsunami warning focal points (TWFPs) on the Global Telecommunication System (GTS) and Internet and all other possible means of communication, Dr Strauch noted that the use of GTS is still in development. Regarding the requirement to provide products in globally standardized formats, CATAC is currently disseminating products in simplified regional formats in Spanish, as this is considered more understandable, especially for civil protection agencies. Finally, relating to the requirement for staff to be able to communicate in English, this is fulfilled with 16 of the 19 staff being fluent in English.

CATAC’s fulfillment of TSP KPIs satisfies all those for earthquake and threat assessment. the required ten-minute elapsed time of the first earthquake bulletin for the TSP area of service (when no coordination is required between TSPs) is performed by CATAC within two minutes. For KPIs pertaining to the TSP functional status, CATAC satisfies all requirements.

CATAC is currently in the process of updating its main software systems from SeisComP3 to SeisComP4/5 for several servers. This upgrade is also being performed by national seismic data centers in other Central American countries. A challenge related to this upgrade is the need to purchase a TOAST license for SeisComP4/5, and funding difficulties related to this upgrade. Nonetheless, CATAC is currently in the process of reviewing options with JICA (2023) or INETER (2024).

CATAC achieved improvements in processing and messaging. Moment Tensor calculation was optimized (with the SCAUTOMT and SCMTV modules of SeisComP), allowing the use of data from accelerographic stations that are not saturated by strong shaking near the epicenter. Results are provided rapidly, with focal parameters of the earthquake and magnitude provided within less than ten minutes, which accelerates the tsunami simulation in real-time and the generation of tsunami products. CATAC also optimized the configuration of the TOAST module for tsunami simulation in its SeisComP system.

The following table presents tests with the principal workstation for the tsunami processing varying the spatial resolution of the bathymetry and the propagation hours of the simulation.

|  |
| --- |
| Results of tests using the principal workstation with TOAST (easy wave module with GPU use) which has a Intel Processor Xeon (LGA2011-3 2.60G 35M Proc E5-2697V3 14C DDR4 Up to 2133MHZ ) and a GPU Nvidia TESLA M40 GPU 12GB GDDR5 Accelerator Processing Card, bought in 2017) **Time in seconds to calculate the tsunami simulation in dependence on the propagation hours** |
|  | **Propagation hours** |
| **Spatial resolution of bathymetry(arc seconds)** | **1** | **2** | **3** | **8** |
| **15** | 29 | 92 | 716 | 1753 |
| **30** | 14 | 32 | 63 | 140 |
| **90** | 7 | 23 | 46 | 143 |

CATAC has a second workstation as a backup for the principal machine with a identical software setup of SeisComP. This workstation has inferior characteristics of the main processor and the GPU and the times of processing are about two times longer than that of the main system.

**Sirens**

In Nicaragua, 20 additional sirens were installed in communities along the Caribbean coast . Together with the 60 sirens already in place since 2015 at the Pacific coast, Nicaragua now has a total of) 80 of these devices for tsunami warning and other emergencies. Thus, most of the population under tsunami danger can receive CATAC warnings by this means. The installation of sirens has also begun in the other Central American countries. CATAC has also worked on the development of other methods for sending messages to the population through social networks, smartphone applications and direct communication between computers. An experimental phone application developed by CATAC allows the user located in a community on the Pacific coast to know the status of the tsunami warning and evacuation routes.

**Recent activities and new projects of CATAC**

Regarding recent activities executed and planned for 2023, a capacitation measure was carried out on a regional scale in February-March 2023 in collaboration with JICA/CEPREDENAC. This work included 15 webinars for all relevant Central American institutions (from Central American countries, Dominican Republic, and Belize) about the use of CATAC’s products. In addition, a capacitation activity is planned about the use of CATAC products for institutions in Panama, in coordination with the CEPREDENAC regional exercise held at this time. Many participants in the webinars proposed to use social networks as Whatsapp or Telegram for the distribution of the CATAC messages instead of or in parallel to email. During the webinar it became also clear that the products of CATAC are not yet included in the SOP of the relvant institutions of the countries. In the webinars it became obvious that the list of recipients of CATAC products (same for PTWC) is often not updated, often only one institution is represented (scientific), there are few contacts. In the discussion the interest was expressed to include more persons and more institutions.

A new project was started with JICA to improve the cooperation of CATAC with the countries and in November 2023, CATAC will be holding an in-person capacitation workshop with all Central American, Dominican Republic, and Belize institutions for one week at CATAC in Managua (in person) about CATAC’s products preceded by a series of ZOOM meetings the week before. There will be also funding for visits to the countries to discuss directly the needs and interests.

CATAC will also support regional tsunami exercises including CARIBE WAVE 23 (March 2023), the CEPREDENAC regional exercise (June 2023), and PacWave 2023 (September to November 2023).

CATAC is currently experimenting with messages and working on the software. During the above mentioned CATAC capacitation webinars, the topic of messages was discussed to finalize the format of these messages within the next few months.

**List of recent improvements and initiatives**

2022 Civil Defense installs 20 sirens at the Caribbean coast of Nicaragua

2022 CATAC starts to integrate GPS data for the definition of Strong Earthquakes

2022 CATAC investigates with numeric simulations the widespread possibility of local tsunamis with very short warning time in all countries of Central America

2022 CATAC reduces the time necessary for initial tsunami simulation with TOAST using magnitude from Moment Tensor with W-phase and escalated durations of tsunami propagation and the precision of the bathymetric model (between 15, 30 or 90 arc seconds)

2022 CATAC starts to test the FINDER procedure from ETHZ for the fast definition of the parameters of large earthquakes for EEW and to investigate the possible use for tsunami warning. FINDER uses high frequency seismic data from a large number of stations.

2022 CATAC starts to develop a concept for the tsunami warning in the big lakes of Nicaragua and the Gulf of Fonseca due to both tectonic earthquakes and volcanic phenomena and landslides form the volcanoes

2022/02 CATAC analyses the SOP of COPECO in Honduras and proposes changes permitting the use of of CATAC products.

2023/01 CATAC is integrated in the administrative structure of INETER on the level of the Executive Directorate

2023 CATAC prepares and carries out 15 Webinars (2 hours each) with all recipient institutions of its products (cooperation with CEPREDENAC and JICA). On CATAC procedures and products and improvement and acceleration of interaction. CATAC will support CEPREDENAC in the 3rd regional Exercise on Disaster mitigation (June 2023, Panama)

2023/04 CATAC starts a project with JICA on capacitation for institutions in Central America and Belize and Dominican Republic which receive CATAC products (Revision of SOP; CATAC products; exchange of data and cooperation of seismological institutions).

2023/03 CATAC starts to send its messages to PTWC (in Spanish) by email

2023/04 INETER is preparing a project proposal to the government of Nicaragua on the enforcement of CATAC (software licenses, IT hardware especially faster GPU, more redundancy, communications equipment)

**Attachment to the report**

Wilfried Strauch, INETER 20/04/2023 (1st version 21/04/2017)

**Short history of the Central American Advisory Center (CATAC)**

**1992 Tsunami in Nicaragua**

1992 Sep. 1 “Slow” earthquake generates a disastrous tsunami at the Pacific Coast of Nicaragua, 170 killed, extensive destruction. No warning, no scientific and organizational capacity for seismic and tsunami information, no seismic network, no scientific information about tsunami occurrence in Nicaragua and Central America, no experience about the scientific investigation of tsunami in Nicaragua, no knowledge in the population about tsunami. This tsunami makes the population and leaders in Nicaragua very susceptible for measures for the prevention and mitigation of tsunami disasters

**Early measures for tsunami mitigation in Nicaragua and Central America**

1992 Sep. 24x7 seismic duty starts at INETER

1992 reestablishment of the Nicaraguan seismic Network (established in 1975 but collapsed in 1980ies due to the socioeconomic situation of the country), 12 new seismic stations operating

1992- RESIS-CEPREDENAC project starts in cooperation with Norway. Establishment of close cooperation between seismological agencies in Central America; installation of centralized digital recording in all countries; introduction of SEISAN for

1993 Nicaragua/INETER joins Pacific Tsunami Warning System (PTWS)

1995 Tsunami Catalogue of Central America elaborated (Molina, 1995, RESIS)

1996 INETER: National Tsunami Warning System for Nicaragua established. NTWS at INETER, walkie-Talkie radios for comm with coastal communities. In cooperation with Switzerland

1996-2014 INETER executes several national projects on tsunami hazard, mapping, warning

1997 RESIS establishes CASC regional seismological data center at UCR/Costa Rica. Receives seismic event data via Internet from all seismological agencies. INETER is proposed to develop methods for regional tsunami warning.

**Surge of the CATAC proposal**

1998 International Early Warning Conference, Bonn, Germany: INETER proposes a Regional Tsunami Warning System for Central America

2003 INETER proposes to CEPREDENAC the establishment of a regional Tsunami Warning System for Central America

2003 ITSU XX, ICG/PTWS Working Group Central America (WG-CA) established, following a proposal of INETER

2004/12 Extremely disastrous Tsunami in Southern Asia

2005 CEPREDENAC/Central American countries discuss an extended proposal of INETER about the establishment of a regional TWS for Central America. Originally with the idea of establishing the tsunami processing capacities in all seismological centers

2009 As the previous proposal (2005) did not work out, INETER proposes a Central American Tsunami Warning Center (CATAC)

2009, 2011, 2014 3 meetings of ICG/PTWS WG-CA. Discussion of the CATAC proposal. Participation of IOC, PTWS, CEPREDENAC

2010/03 Strong Tsunami in Chile.

2010 INETER elaborates preliminary tsunami hazard maps for all the Pacific coast of Nicaragua

2010 INETER, MARN, COPECO elaborate tsunami hazard maps for the Fonseca Gulf, in cooperation with regional project on risk analysis with GIS, BGR, Germany.

2011/11 Giant and deadly tsunami in Japan.

2012 OSOP establishes Seismological Software SeisComP3 in all Central America Countries and real time data exchange is greatly enhanced, a scientific-technical pre condition for CATAC

2012/08/26 M7.3 “slow” earthquake generates a tsunami (5m runup) at small strips at the Pacific coasts of El Salvador and Nicaragua. Confusion in the immediate evaluation of this event by the seismological agencies in both countries. UNESCO/NOAA provide assistance for the evaluation of the impact.

2013 Nicaragua requests support from Japan for the establishment of CATAC at INETER

2014-2015 Information gathering, Assurance of regional/international support

**Establishment of CATAC and recognition by the UNESCO system**

2014/12 JICA Mission visits Central America on CATAC

2015/04 JICA Report on CATAC “In Central America, Nicaragua has the best conditions for a CATAC”

2015 Nicaraguan government offers to SICA to establish CATAC at INETER in Managua

2015 “Regional Seismic Network” Established – Seismological institutions of Central America support Nicaraguan CATAC proposal

2015 Letter of CEPREDENAC (civil protection institutions of Central America) to UNESCO supporting Nicaraguan CATAC proposal

2015 Apr: ICG/PTWS XXVI: Nicaragua receives support for CATAC to be established at INETER

2015 May: ICG /Caribe TWS: Nicaragua receives support for CATAC to be established at INETER

2015 Aug: IOC-General Assembly: Nicaragua receives support for CATAC at INETER

2015/08 JICA mission in Nicaragua, preparation of cooperation agreement on CATAC

2015 Final Decision of Nicaragua on the establishment of CATAC at INETER, Nicaragua for both the Pacific and Caribbean coasts of Central America

2015 INETER starts to develop CATAC. Capacitation, proposals for related projects, improvement of monitoring center

2016/01 INETER starts a project with ETHZ Zurich on Earthquake Early Warning EEW. Close cooperation with JICA project on CATAC.

2016/08 JICA Mission: Cooperation agreement Nicaragua-Japan (JICA) signed

2016/10 – JICA Consultant Dr. Furukawa arrives – The CATAC Project starts

2016-2019 Improvement of CATAC with support from Japan: SeisComP PRO software with TOAST, computers, 8 bb new seismic stations in Nicaragua, support for 8 sea level stations in Nicaragua, virtual seismic network with 600 stations, intense capacitation in Japan and Nicaragua, master studies in Japan (in 2023 CATAC has 7 masters on seismology and tsunami)

2017 UNESCO project on SOP for Tsunami mitigation in Central American countries

2017 Civil Defense installs 60 sirens on the Pacific coast of Nicaragua

2019/04 ICG/PTWS in Montelimar Nicaragua: CATAC is accepted to work in preliminary/experimental mode

2019/05 ICG/Caribe EWS in Costa Rica: CATAC is accepted to work in preliminary/experimental mode

2019/07 CATAC Users guide (preliminary) is elaborated containing the delineation of the Service areas and monitoring areas

2019/10 JICA project on CATAC finishes. Japanese consultants evaluate: “CATAC fulfills technical conditions for acting as TSP”

**CATAC operates in experimental/preliminary mode and is improving further**

2019/10 CATAC starts to employ 2 watch standers in 24x7 shifts. 7 new watch standers to be capacitated in the following months. CATAC starts sending messages on seismic events to the recipient institutions

2020/03 COVID limits exchange and cooperation. CATAC works normally but cooperation with

2020 Tsunami database established at CATAC (in 2022 bugs were found and a detailed revision started)

2020 Improvement of INETER´s seismic network with 30 short period seismic stations

2020 CATAC elaborates an application for cellphones on tsunami warning in Nicaragua including an interactive map on the tsunami hazard at the location of the user and evacuation routes

2020 CATAC starts to support COPECO/Honduras in the seismic and tsunami monitoring while the Honduran seismic network due to COVID measures

2021 Installation of accelerometers Nicaragua (25), El Salvador (25), Guatemala (17), Costa Rica (4) within the EEW project with Switzerland; Drastic improvement of detection and location capability of CATAC and possibility to use FINDER especially in the N of Central America.

2021 three further members of CATAC staff start Masters studies at UNAN university in Managua

2021/12 ICG/PTWS: CATAC is accepted to start working routine mode in Jan 2022

**Recent improvements**

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Proposal

Recommendation ICG/CARIBE EWS-XVI

**Start of Operation of Central America Tsunami Advisory Center (CATAC)**

The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS),

**Considering** the report of the fourth meeting of the Regional Working Group for Central America of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS), held in Managua, Nicaragua, on 11 February 2019, and the recommendations of the fifth meeting of the Regional Working Group for Central America of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS), 15 November 2021 (Online) and the sixth meeting of the Regional Working Group for Central America of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS), 24 April 2023. Considering also the decision of the XXX meeting of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS), December 2023, about the start of operation of the CATAC for the Pacific coast of Nicaragua.

**Considering** recent tsunamis on the Pacific (September 1992 and August 2012) and Caribbean Central America coasts (1991, 2009 and 2018), and the potential loss of life and economic impact caused by such possible future events,

**Considering** the Coordination Centre for the Prevention of Natural Disasters in Central America (CEPREDENAC) as the institution specialized in integrated disaster risk management in Central America and that harmonizes the approach to these priorities with the strategies and agendas of other specialized bodies of the Central American Integration System (SICA),

**Considering** the efforts of Central American countries and regional organizations to establish new seismic stations, to maintain existing stations, and to make progress in the exchange of seismic data so as to advance tsunami and earthquake warning and research capabilities in Central America,

**Recalling and appreciating** the technical cooperation provided by the Japan International Cooperation Agency (JICA) to Nicaragua for the creation of the Central America Tsunami Advisory Centre (CATAC) and the strengthening of the regional system, including technical training,

**Decides** to support the efforts and progress made by Nicaragua in the creation of the Central America Tsunami Advisory Centre (CATAC), as a tsunami service provider (TSP) within the framework of the ICG/PTWS;

**Also recalling** that CATAC has been on trial mode as of August 2019;

**Decides** to start CATAC's full functionality as of XXX YY, 202Z

Financial implications: None