MARMOR

Marine **A**dvanced geophysical **R**esearch equipment and
Mayotte multidisciplinary **O**bservatory for research and **R**esponse

LE POINT A MI-PARCOURS

L. Géli
MARMOR P. I.
GEO-OCEAN, Ifremer

Objective 1 : Mobile equipment for marine seismology & geodesy

EPOS-FR
EUROPEANPLATEOBSERVINGSYSTEM FRANCE

- Axis 1 : mobile equipment for marine geodesy

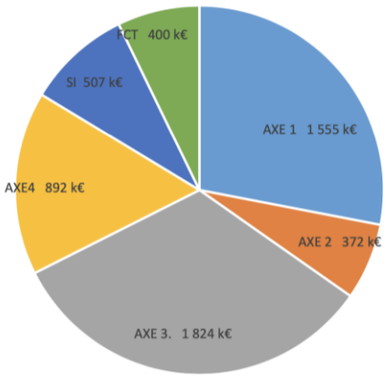
- Axis 2 : mobile equipment for rapid intervention

- Axis 3 : OBSs for imagery, solid earth research and marine environnement

- Axis 4 : R&D Fiber Optics Applications for marine seismology and geodesy

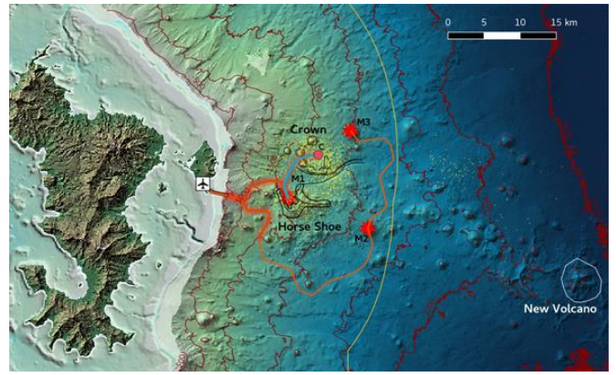
- Information System and structuration of the french national community

AXES 1 à 4 + SI + FCT (5,550 M€ nets) - REPARTITION

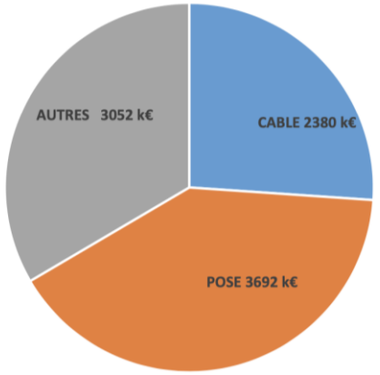


Objective 2 (Axis 5) : Submarine cabled observatory for permanent, real-time, *multi-disciplinary* monitoring of seismo-volcanic hazards in Mayotte (H24, 7/7)

REVOSIMA



AXE 5 (9,124 M€ nets) - REPARTITION PAR POSTES



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OBJECTIVE 1
Axis1, 2, 3, 4 + S.I.

EPOS - FR
EUROPEANPLATEOBSERVINGSYSTEM FRANCE

IMPLEMENTATION PHASE

Axis 1 : Mobile Equipment for Marine Geodesy

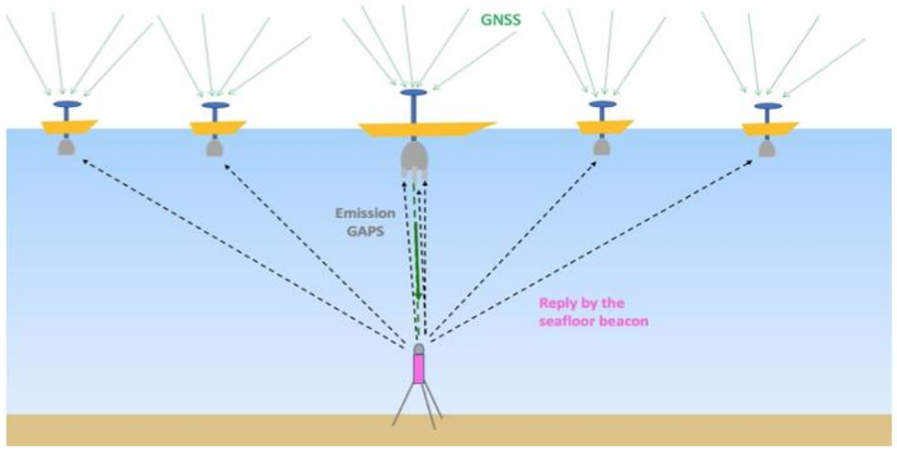
HORIZONTAL MOTIONS
Acquisition for GNSS/A & INS

- **Unmanned surface vehicle segment (710 k€)**

- 1 fleet of 4 auxiliary surface drones
- 1 Master USV equipped with an Ultra-Short BaseLine - USBL

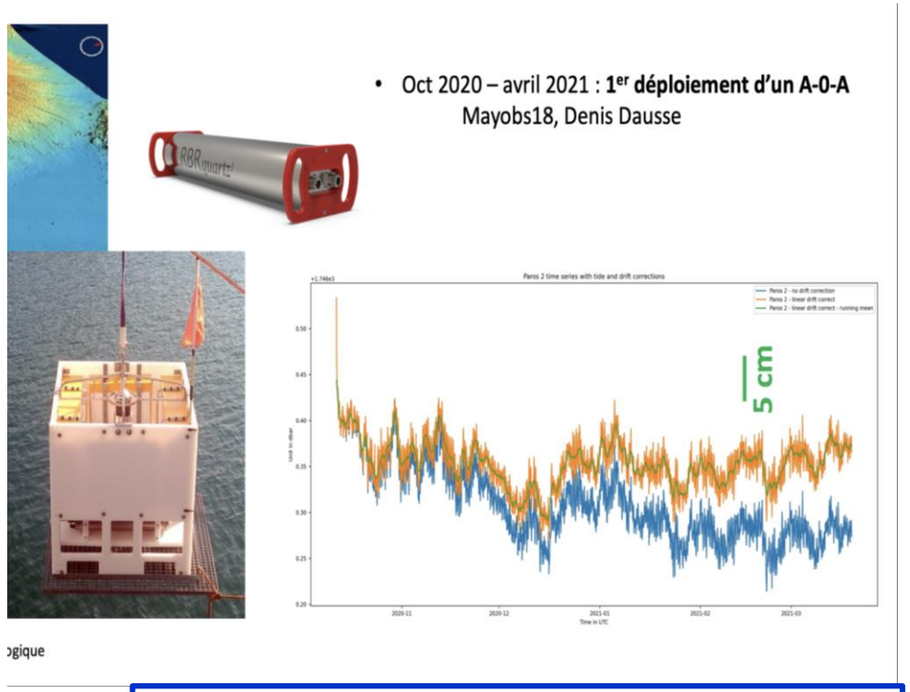
- **Acoustic segment for** GNSS/**A (505 k€)**

- Acoustic head (GAPS) with gyroscope and omnidirectional *acoustic* antenna
- Acoustic beacons CANOPUS



VERTICAL MOTIONS
Acquisition of absolute Pressure Gauges (350 k€)

- **3 A-O-A low drift (< 1mm/y)**
- **4 standard RBR**



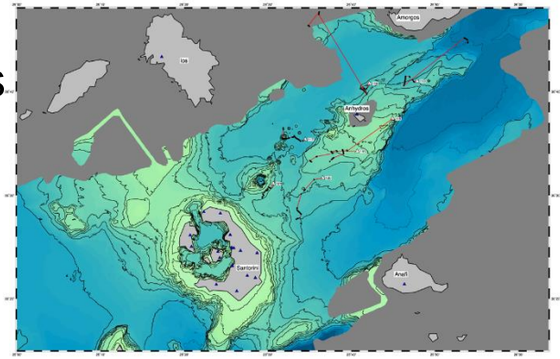
Synergies with other projects
DEEP-C, GEO-ADAMS, MATTIS (ANR)
SeaSALT (ERC), MAYOTTE (REVOSIMA), SWOT-ALISOTTER-X

Synergies with other communities
Physical Oceanography
Solid Earth Geosciences

AXIS 2 : mobile equipment for rapid intervention

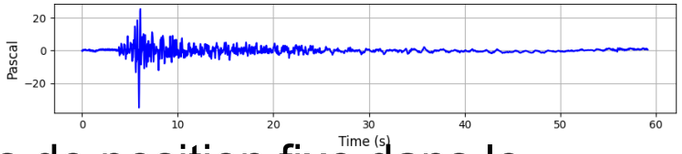
Acquisitions:

- **2 OBS très compacts** pour être envoyés rapidement par avion, déployable par un navire d'opportunité (Oct. 2025)+**5 demandés** dans le projet PEPR IRIMA.
- **8 flotteurs dérivants** pour envoyer à la demande des données par iridium (Août 2024)
- **Capteurs de pression** pour enregistrer les glissements asismiques (mutualisation instrumentation Axe 1)



Comment gérer/suivre une crise ?: Test sur la crise de Santorin (déployé mars/oct. 2025)

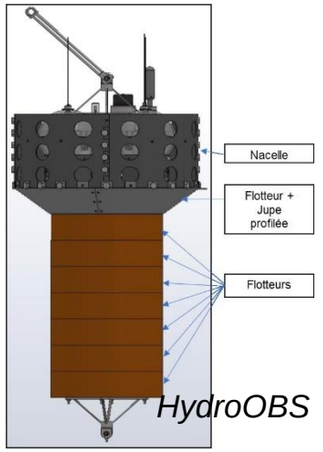
Nouveau concept : utilisation des flotteurs pour le suivi en temps quasi–réel de la sismicité



- Création d'un format de métadonnées spécifique pour les flotteurs (pas de position fixe dans le temps)
- Création d'un logiciel gérant les données arrivant sur le serveur pour une localisation automatique (en cours)
- Gestion des erreurs de localisation des flotteurs sur la localisation de la sismicité (en cours)
- Modalités des interactions avec les autorités locales lors du suivi (à faire)

Axis 3 : POOLS FOR MOBILE MARINE SEISMOLOGY

2022: Action spécifique Epos-France « sismologie marine mobile » et son parc instrumentale crée grâce au projet MARMOR (https://smm.epos-france.fr/sismologie-mobile-marine/historique/)



HydroOBS

2023: Labélisation « Parc d'Instruments Nationale » par l'INSU Instrumentations


ASOBSs

OBSs sismique active (ASOBS)

- 23 Instruments (Sercel micrOBS) reçus le 21 octobre 2025
- Demandes utilisation: Mayotte 2026, Vanuatu, Equator, N Calédonie 2027

OBSs compact broadband 1 an autonomie (C-BBOBS)

- 2025: 5 Instruments commerciales (KUM Nammu) reçus par Géoazur le 19 novembre
- 2025: Prototype d'instrumentations propriétaires construit en octobre, prêt pour validation

C-BBOBS KUM

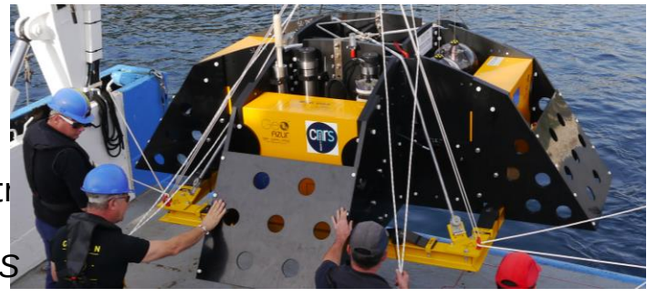

C-BBOBS IPGP

R&D geophysics, ocean-bottom platforms

- Jouvence du MUG-OBS de EMSO-Ligure
- 2024: Redéployé en octobre 2024 avec CTD et capteur de pression A0A ajouté.

Autonomous hydrophone (HydrOBS)

- Nouveau nacelle, navettes et équipement ancillaire acheté
- Déployé à Mayotte en janvier 2024 avec deux autres nouvelles instruments achetés avec d'autr financements



MUG-OBS

Element 4: R&D on Fiber optics applications to marine seismology and seafloor geodesy

- Optical sensors based on Fabry-Perot interferometry (311 k€)

Optical Seismometer **(125 k€)**: ESEO (67 k€) worked on the optimization of the performances of the LOKI interrogator acquired by IPGP (30 k€). IPGP constructed the pendulum system for the optical seismometer (5,2 k€) and improved the calculation and the calibration of the associated transfer functions (22,3 k€).

Optical pressure meter **(186,7 k€ spent out of 250 k€)**: ENS acquired and adapted a pressure chamber (500 bars) specifically designed to conduct different tests in view of the marinisation of the absolute pressure prototype (registered patent *:* Frédérick Boudin PSL/CNRS: FR3150288A1, WO2024261138A1).

- **DAS (297 k€).** MARMOR funded the acquisition of the DAS interrogator (142 k€) implemented for LIDO, the Ligurian DAS observatory, as well as the development of the Information System for DAS A- and B-Nodes (155 k€). .

Bragg grating technology (130 k€). The MARMOR project invested 130 k€ on R&D to improve the accuracy of time measurement methods by using an extensometric sensor based on readily available telecom components and Bragg gratings.

Information System: integration of marine seismological data within EPOS-France

A-node for OBS data. This task received a 155 k€ grant as part of MARMOR's IT budget. To date, €112,000 has been spent on a 23-month fixed-term contract dedicated to the co-development of node-A SMM, located at IPGP, in partnership with permanent personnel of DT- INSU.

A-Node for DAS data. The DAS node also received a 155 k€ grant for personnel expenses as part of MARMOR's IT allocation, for the implementation and optimization of DAS acquisition on the Monaco-Savonne cable. The integration of DAS data into the Sismoazur processing chains to monitor submarine earthquakes represents a major achievement (operational in September 2025).

B-Node (for OBS and DAS). A third grant of 127 k€ for the hiring of temporary staff has been awarded to OSUG to prepare a tool to optimize the integration of new networks, particularly fiber data, into node B of the SI-S. This work requires node-A (“OBS” and “DAS”) to be operational, and is therefore currently underway, with the recruitment of Pablo Garcia Campos on February 1, 2025, for two years

OBJECTIVE 2
Axis 5 : cabled seafloor observatory in Mayotte

Evolution from inital architecture to SMART Cable

EN JUIN 2021, LE PROJET A COMMENCÉ AVEC UN DÉFICIT DE 2,5 M€ ET UN RISQUE FINANCIER CONNU ET ACCEPTÉ AB INITIO PAR LES PARTENAIRES ET L'ANR.

EN 2022 ET 2023, LE DÉFICIT N'A CESSÉ DE SE CREUSER JUSQU'À ATTEINDRE PRÈS DE 7 M€.

UNE SOLUTION ALTERNATIVE A DONC ÉTÉ RECHERCHEE ET TROUVEE EN 2024, FONDEE SUR LA TECHNOLOGIE « SMART CABLE ».

EN 2025, LE PROGRAMME FRANCE 2030 A ACCORDE AU PROJET UN BUDGET COMPLEMENTAIRE DE 6,57 M€, SOUS RESERVE DE VALIDATION DE LA SOLUTION « SMART CABLE » PAR LE COMITE D'EVALUATION SCIENTFIQUE MIS EN PLACE PAR L'ANR.

What is SMART Cable ?

SMART = Science Monitoring And Reliable Telecommunication

United Nations effort uniting science and telecom industry

Joint Task force

ITU = International Telecom Union
IOC = Intergovernmental oceanographic Commission
WMO = World Meteorological Organisation

Provides the necessary strategic direction and leadership leading to the development of a sustained SMART subsea cable network

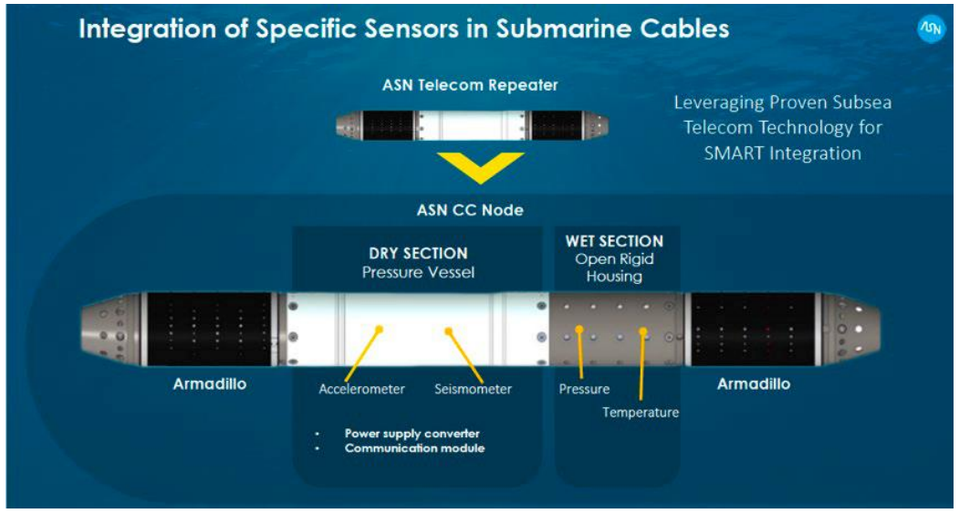
→ **<u>disaster risk reduction</u>**

- Monitor **climate change** observables
- provide **early warning for earthquakes and tsunamis**
- Monitor **seismic activity** for earth structure and related hazards.

Existing / under development systems :
Vanuatu-New Caledonia, InSEA wet demo, SMART Atlantic CAM

ASN « Climate Change nodes »

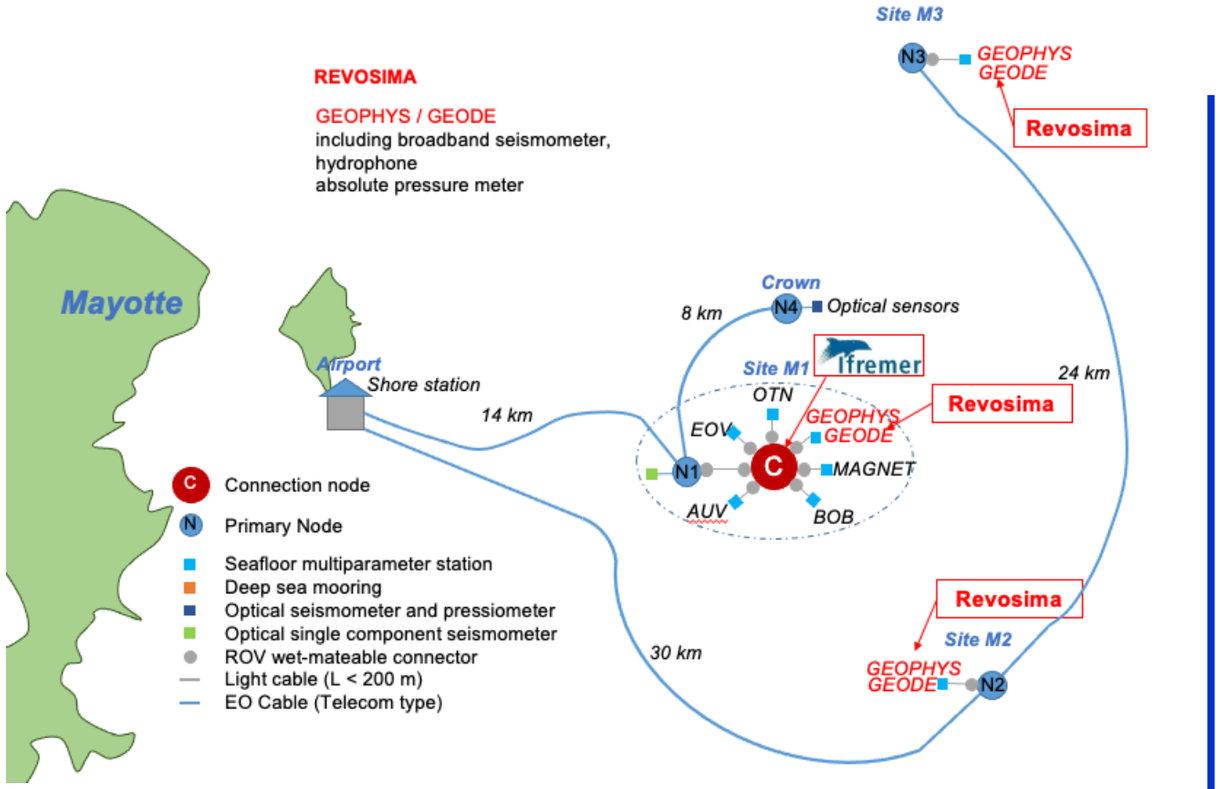
was not available at project started 2021



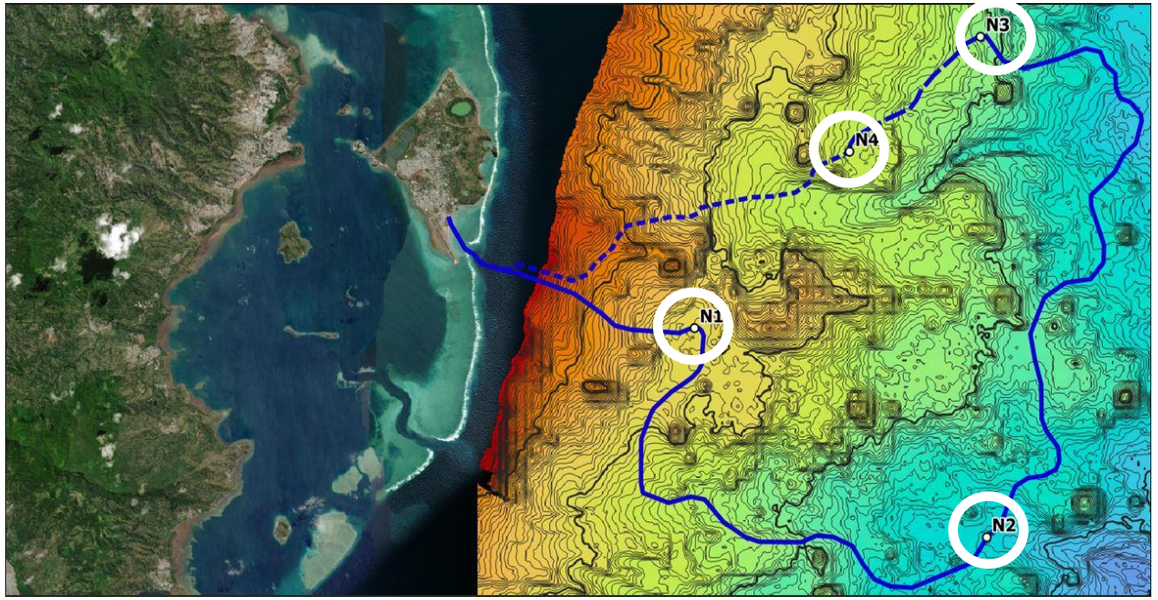
<u>Sensors :</u>
sismometer 3C, accelerometer
absolute pressure A-0-A
Bottom Water Température
Optical fibers dedicated to DAS
End of development and qualification = Q2 2026

Initial vs. SMART

Initial Architecture



Proposed Architecture «SMART»



SMART SENSORS COMPLY WITH PROJECT OBJECTIVE PRIORITY 1 (SUBMARINE MONITORING OF SEISMO-VOLCANIC HAZARDS IN MAYOTTE) AND REDUCE DEPLOYMENT COMPLEXITY

Ifremer

* complementary non-permanent monitoring of water column possible using glider (did not exist in 2020)

Smart Solution :

1) Allows Submarine Seismo-volcanic Monitoring in Mayotte (Project Priority 1)

2) Reduces Deployment Complexity

		SENSOR			SMART CABLE	
Geophysics	Seismology	3C-BROADBAND			+	OK
		Accelerometer			+	OK
		Hydrophone			-	NO
		DAS			+	OK
		Optic seismometer			-	Transfered to Axis 4
	Geodesy	A-0-A pressure gauge			+	OK
		Optic-pressure meter			-	Transfered to Axis 4
	Magnetotellurics	Electro-magnetics			-	NO
Geochemistry	Fluid emissions/Geochemist	Acoustics (Bubbles)			-	
		AUV borne CO_2			-	Intermittent glider survey**
		AUV borne CH_4			-	

** Complementary non-permanent monitoring of water column possible using glider (did not exist in 2020)

Mayotte cabled observatory governance

During MARMOR project 2026-2029

Ifremer MARMOR project leader (2 objectives)

Tender carried out by IPGP with technical and administrative support from Ifremer

Funds to be transferred from Ifremer to IPGP

IPGP infrastructure owner and operator

Beyond MARMOR project (>2029)

IPGP infrastructure owner
IPGP operator on behalf of REVOSIMA

MAPPPROM funds operating budget * via REVOSIMA

* Estimated yearly cost = 66,6 k€ (incl 2OCAM membership)

MAPPPROM funds repair in case of cable break up with government emergency budget