

The SMART cables initiative: equipping sub-sea communications cables with new capabilities for tsunami warning and climate change monitoring

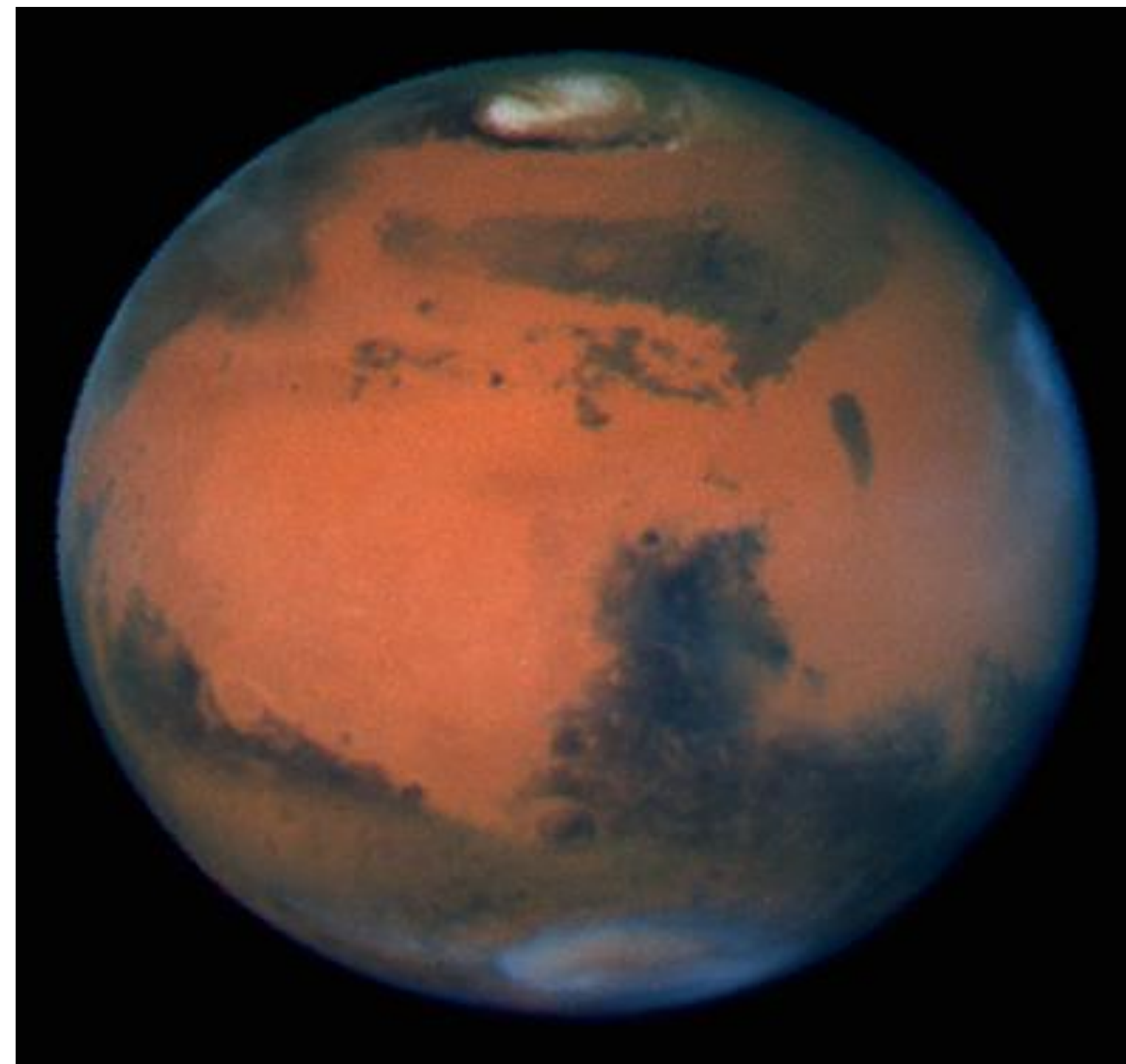
Science, Monitoring And Reliable Telecommunications

David Meldrum
Scottish Marine Institute





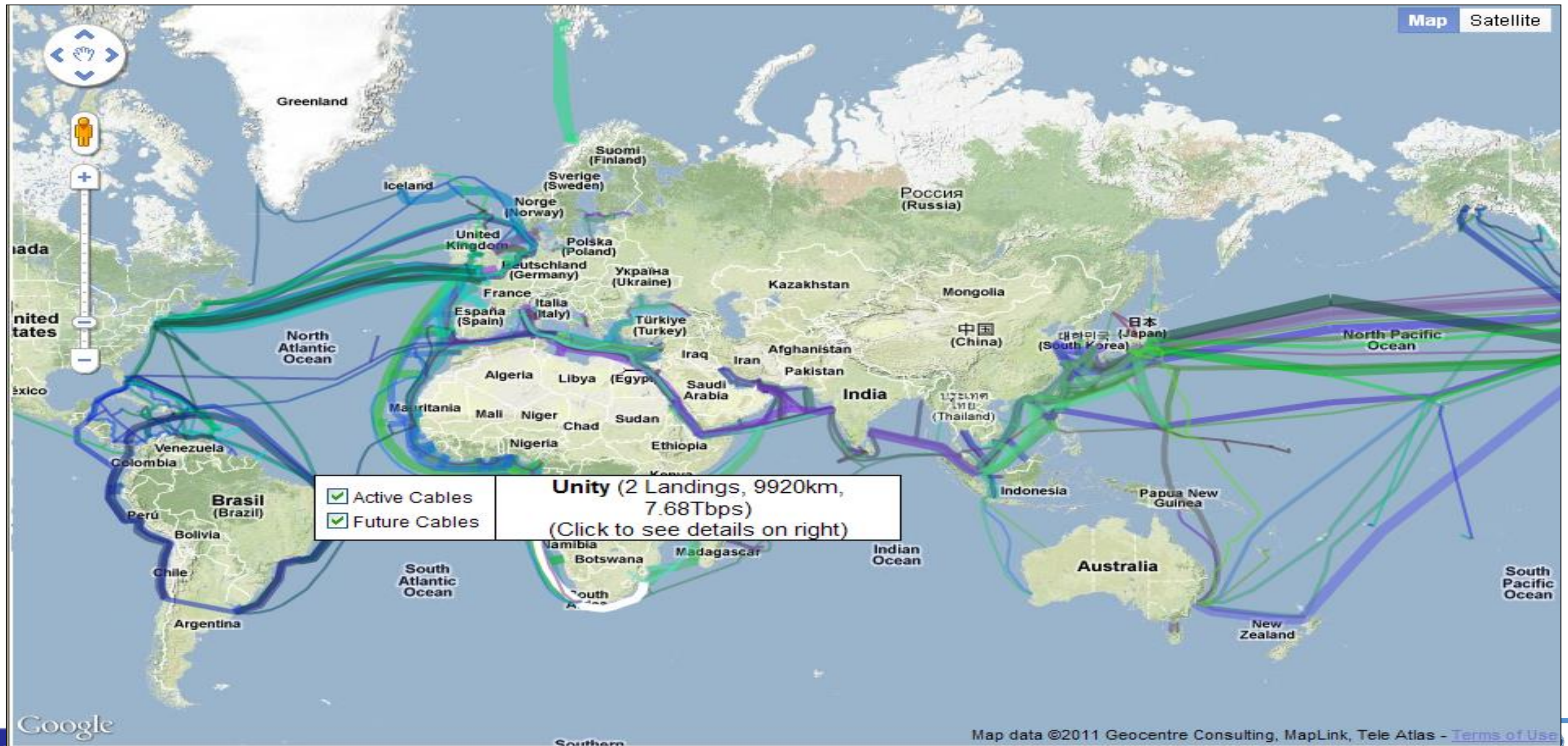
Blue Planet



Red Planet



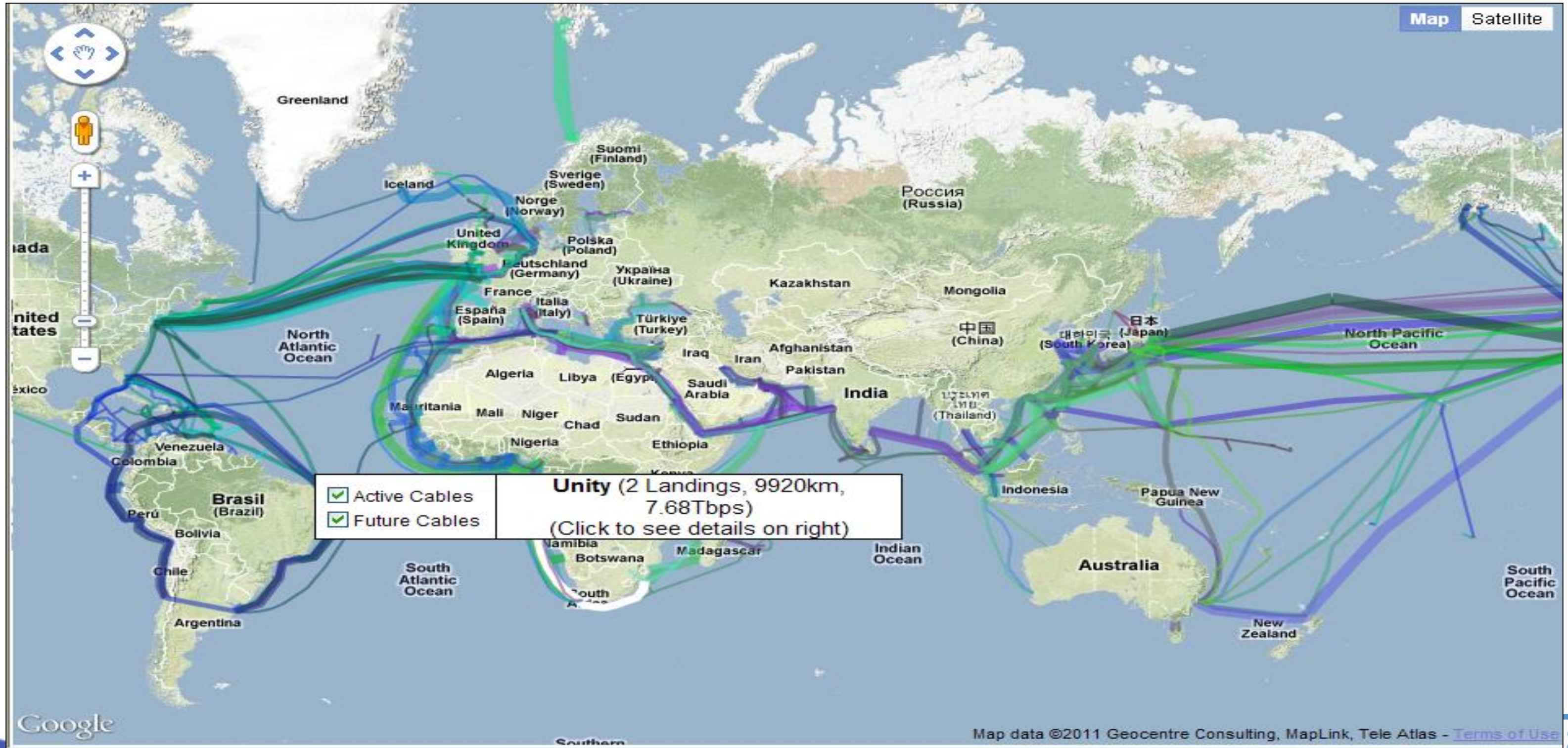
The global oceans are traversed by > 1 million km of comms cables:
might they in future also serve other purposes?



IOC



Where it started: Rome workshop 2011, hosted by the ITU
Submarine Cables for Ocean/Climate Monitoring and Disaster Warning: Science, Engineering, Business and Law



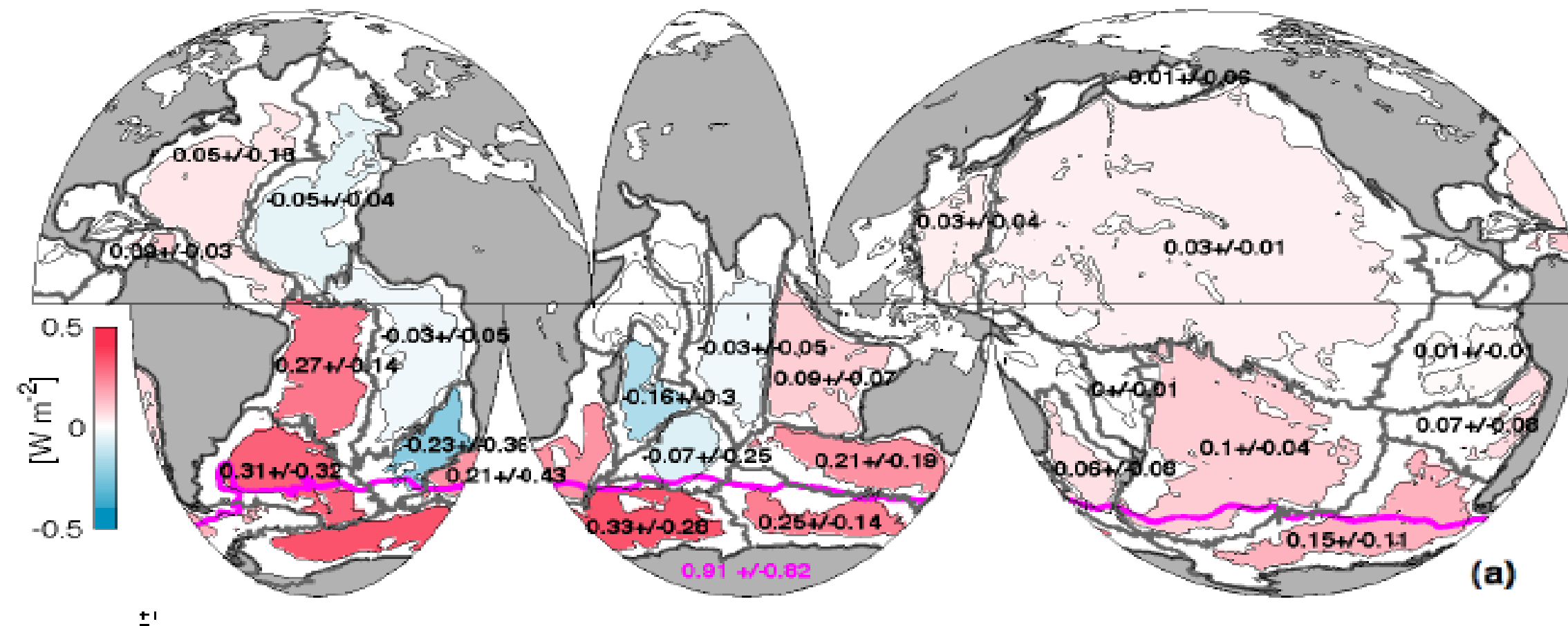
Submarine Cables for Ocean/Climate Monitoring and Disaster Warning: Science, Engineering, Business and Law

- ITU initiative stimulated by
 - 2010 *Nature* paper by John You, U of Sydney
 - 2010 Plenipotentiary resolutions on role of ICT in disaster warning/mitigation and climate change
- Workshop during ITU Green Standards Week: Rome, Sept 2011
- 40 attendees
 - 5 scientists
 - 5 regulators
 - 10 engineers
 - 10 cable companies (ICPC members)
 - 10 legal advisors

The evidence for climate change: deep ocean temperatures

Abyssal & Deep Heat Content Changes

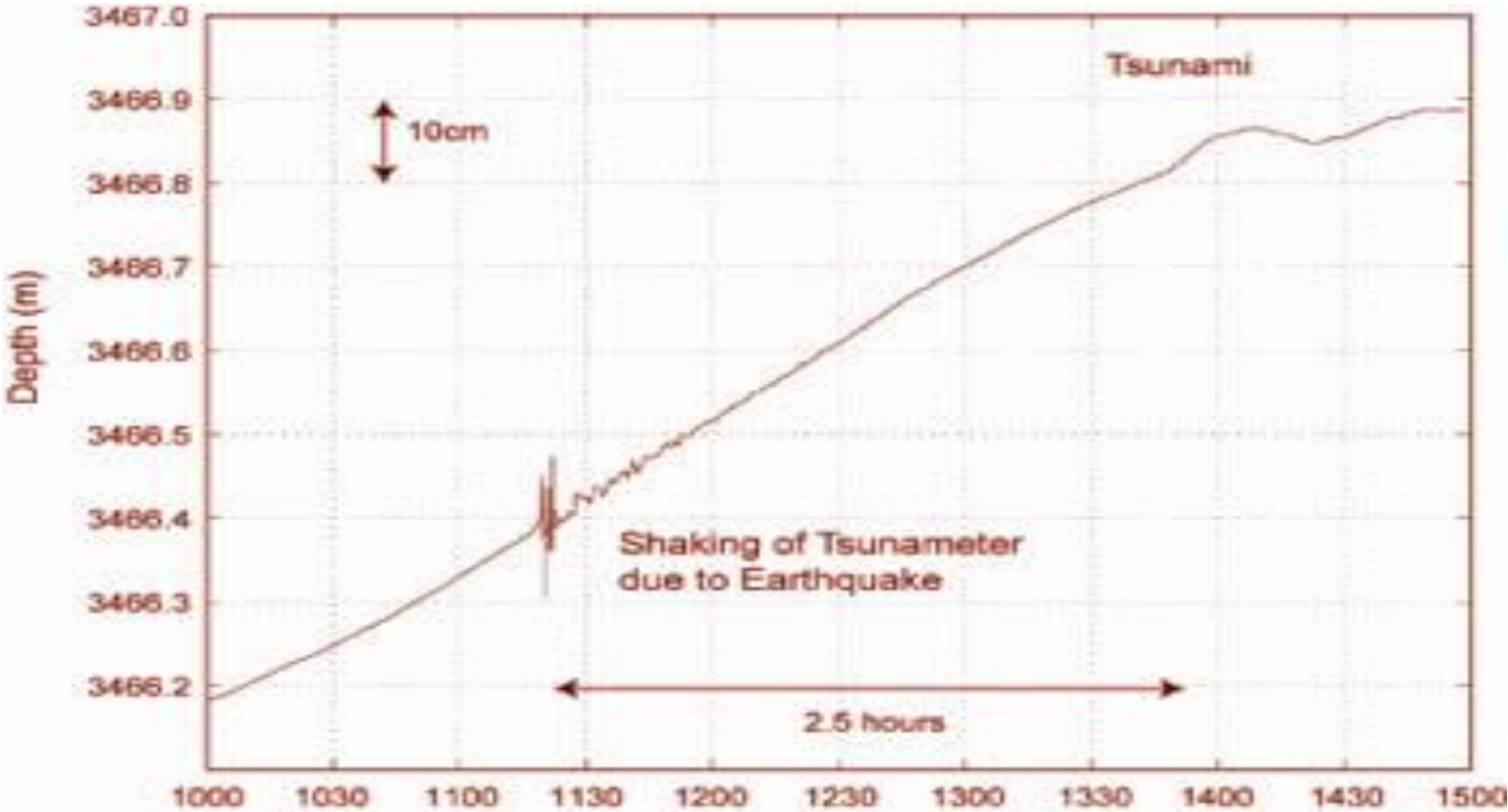
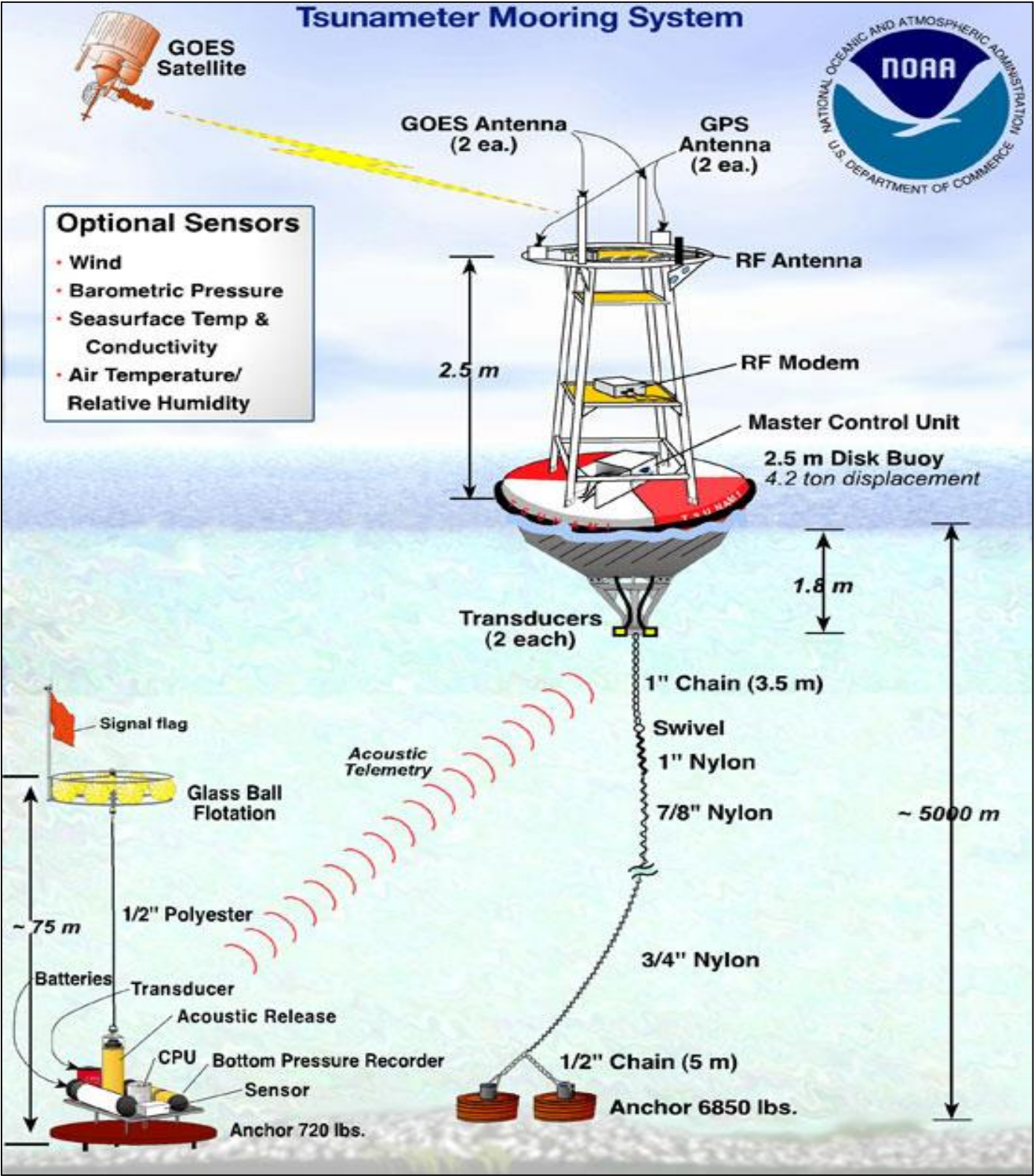
(Purkey & Johnson, 2010)



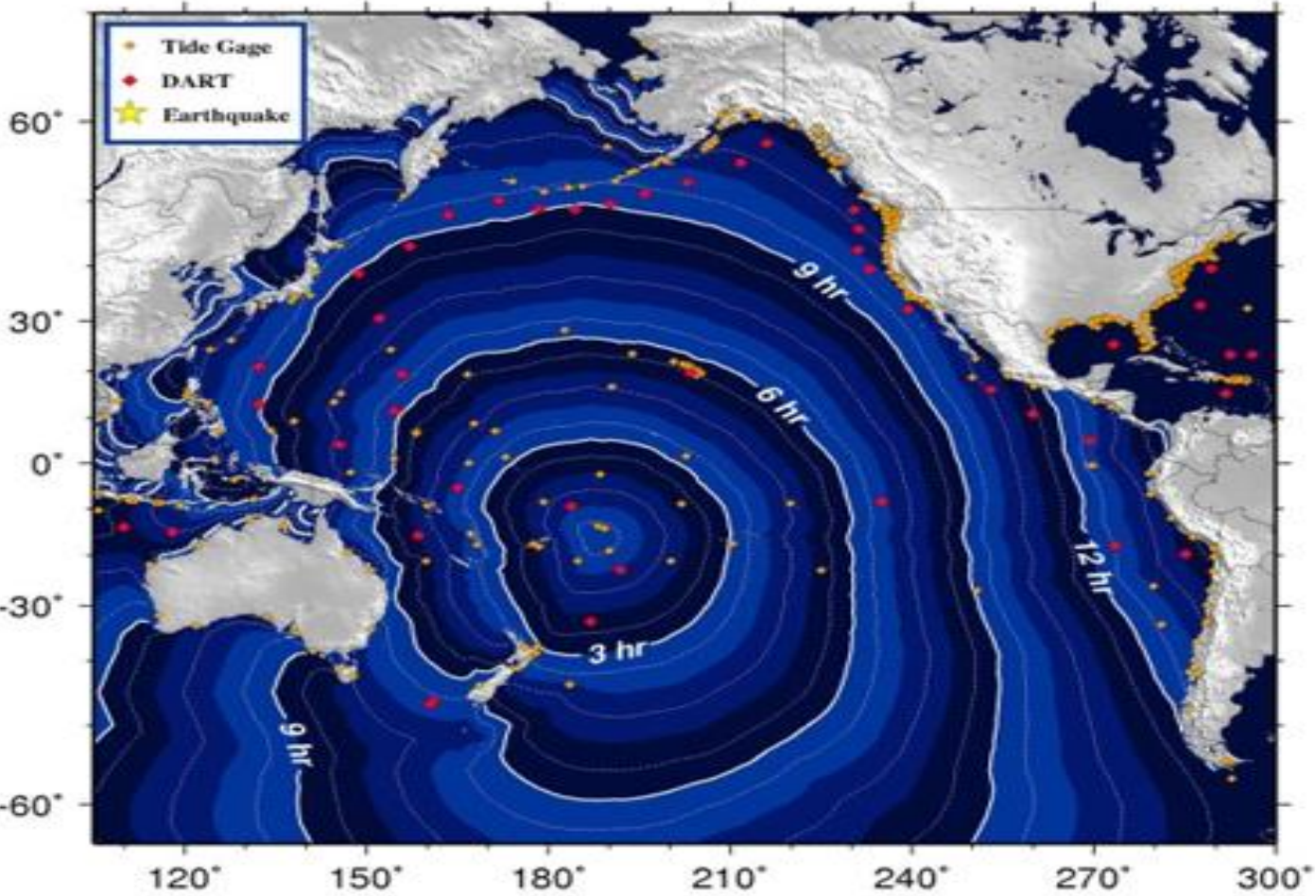
Region	Global Heat Gain (W m^{-2})
Abyssal Ocean ($z > 4 \text{ km}$)	0.027 (± 0.009)
Southern Ocean ($1 > z > 4 \text{ km}$)	0.068 (± 0.062)
Total (Abyssal + Southern)	0.095 (± 0.062)

- Deep ocean warming $\sim 1/7^{\text{th}}$ of upper ocean 1990s to 2000s

Disaster warning - tsunamis



Tsunami Travel Times



GMT 2009 Sep 30 00:27:05 UTC

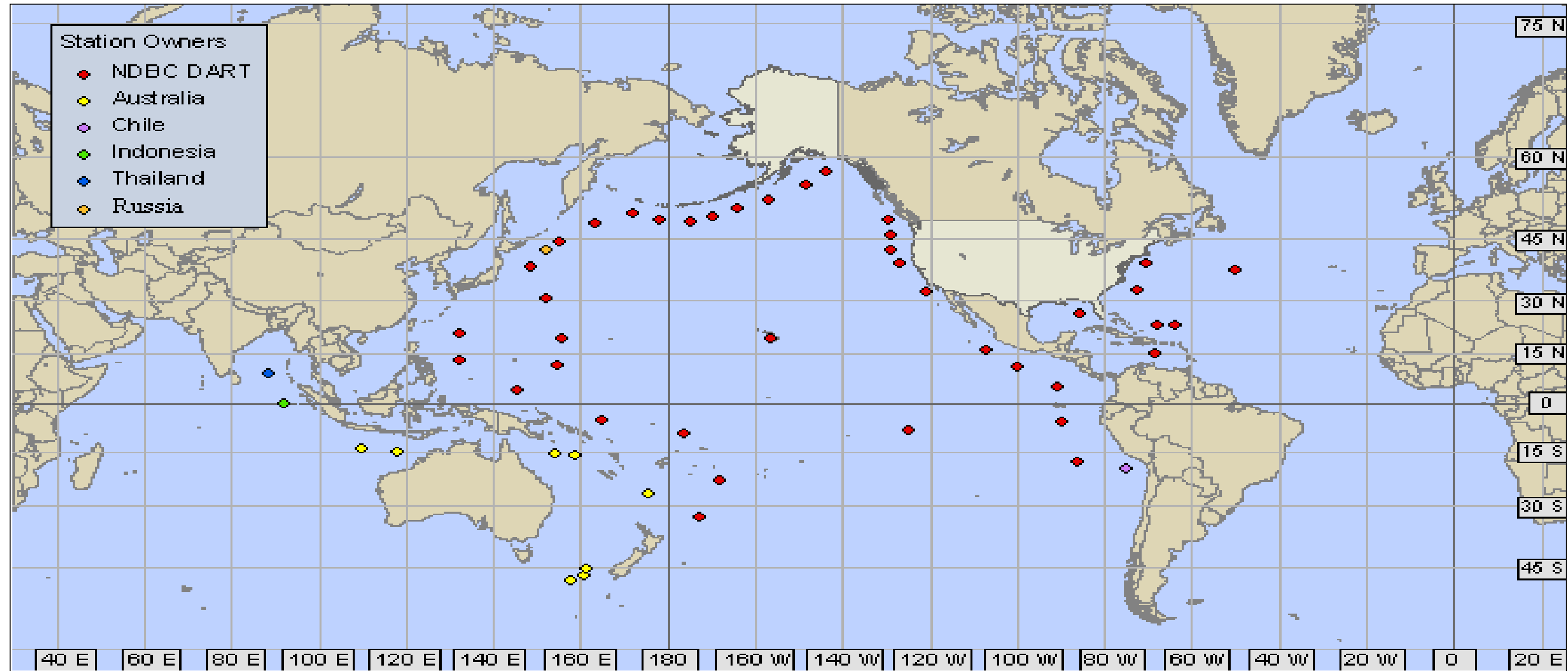


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Joint Task Force
SMART SubSea Cable Systems

Tsunami warning networks



>25% of network out of action

Vandalism is a major problem



Figure 16. Australian Tsunameter - Stolen Superstructure and Electronics Payload



Figure 17. Indian Tsunami Buoy – Stolen Superstructure and Electronics Payload



Figure 18. German GITEWS Tsunami Buoy – Stolen Superstructure and Buoy Payload

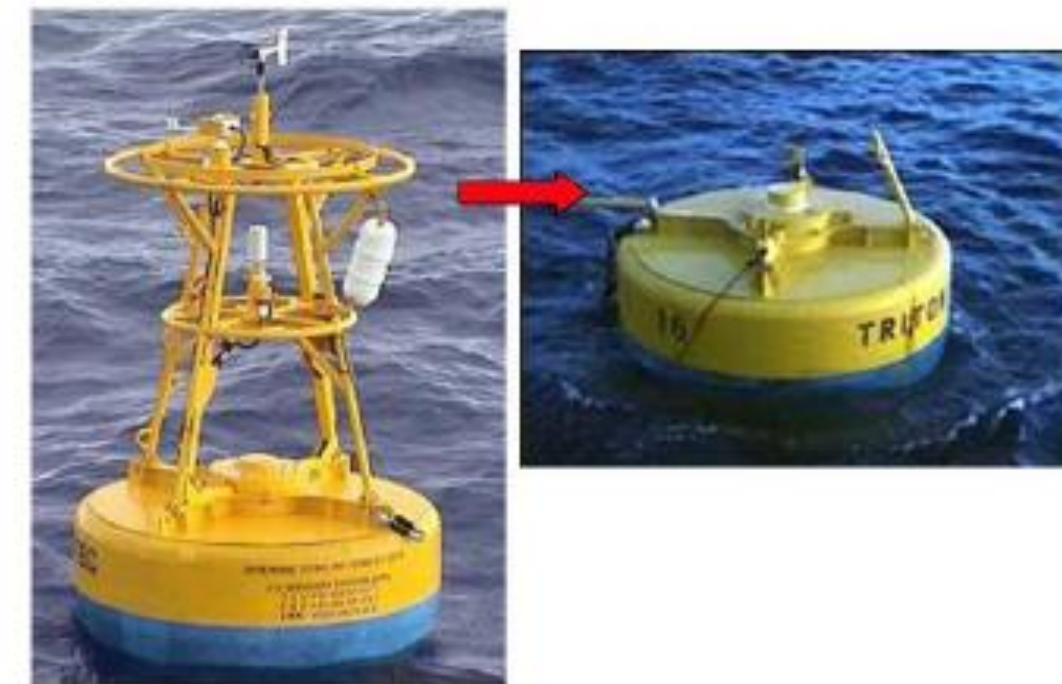
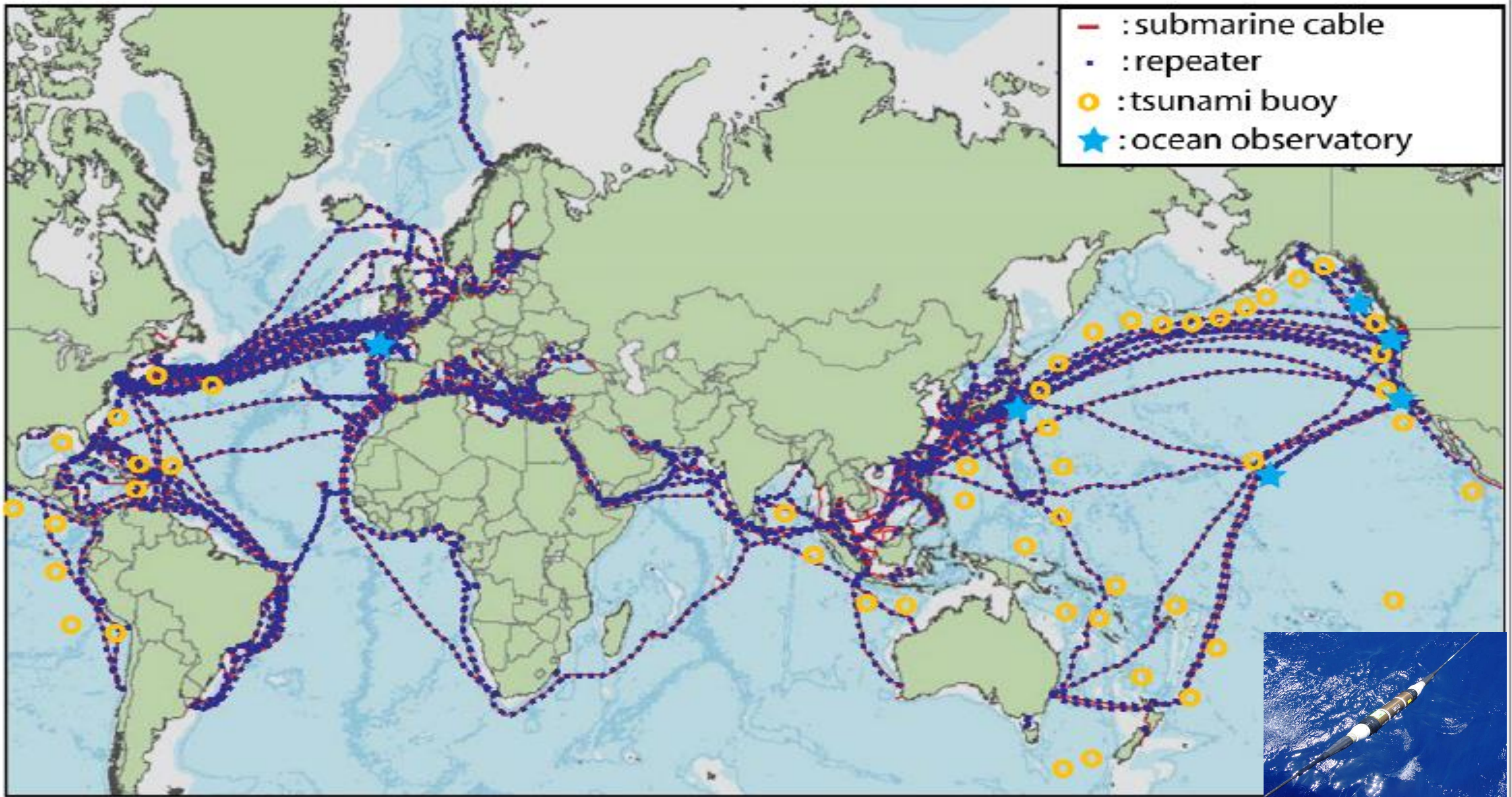
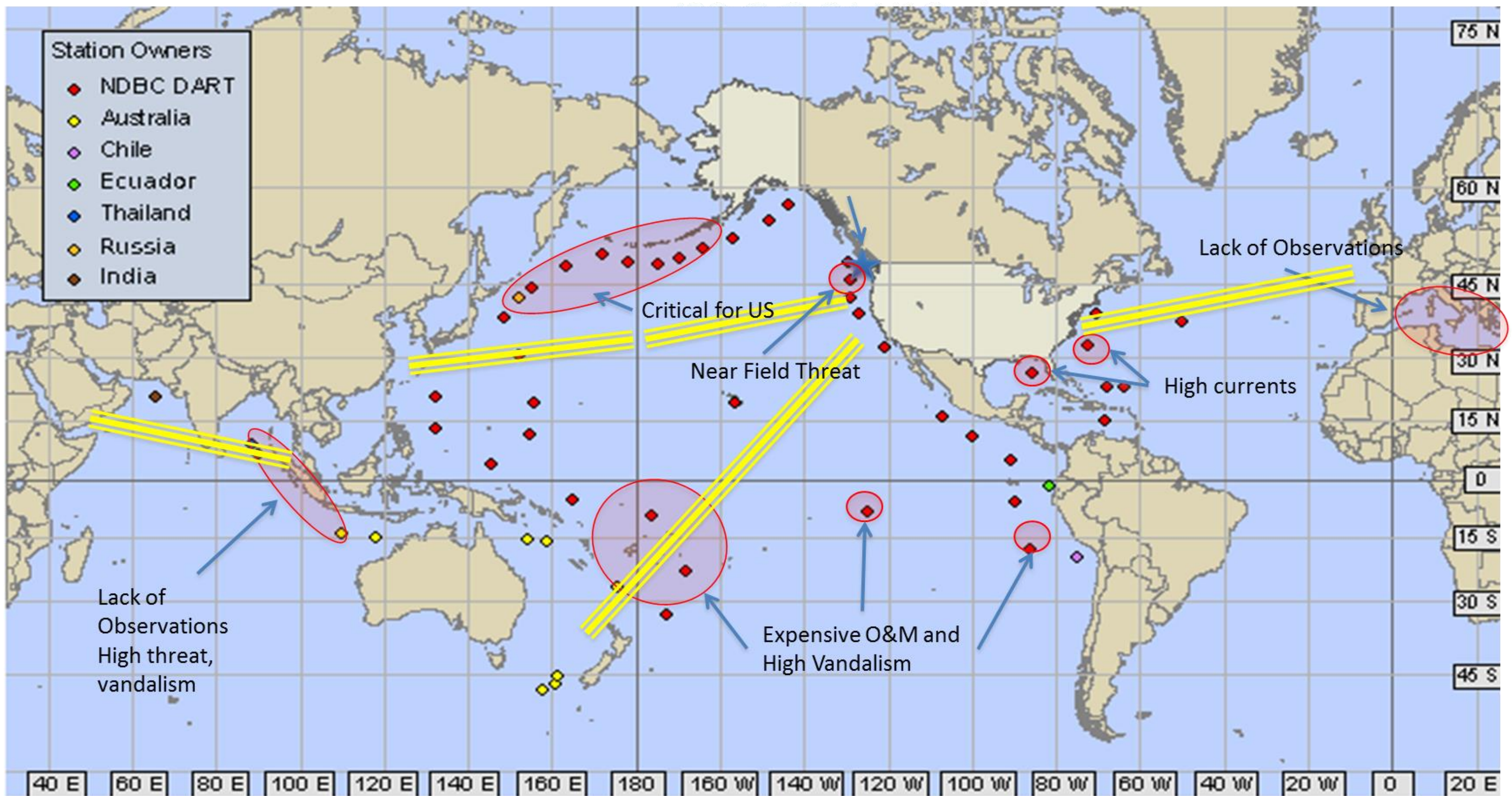


Figure 19. Broken and Stolen TRITON Tower



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Cables offer a solution

- Vandal-proof in the deep ocean
- Instantaneous communications
- Energy source
- Next generation commercial repeaters to include built-in tsunami sensors?
- Why not other sensors as well?
 - Ocean properties such as temperature and salinity
 - Seismometry
 - Passive acoustics
- Suggestion: establish a small enthusiastic group to sketch out a limited pilot tsunameter project

Outcome

- Cable operators reluctant to get involved
 - Impact on integrity of cables
 - Costs
- Legal reps extremely negative
 - Cable operators enjoy a liberal legal framework
 - Marine science does not
 - Verdict: project sentenced to death, appeals disallowed!
- The End



Outcome

- ‘World Café’ negotiation process initiated
- Outcome doc agreed
- Study group to be convened by IOC/ITU/WMO
 - Define needs
 - Investigate technical feasibility
 - Sketch out pilot project: tsunametry strong candidate
 - Build trust and confidence
 - Demonstrate impact
 - Estimate costs
 - Identify partners
 - Report back to next workshop
- Longer term
 - Draw up business model
 - Study legal aspects

Progress since September 2011

- Establishment of 'Joint Task Force'
 - itu.int/ITU-T/climatechange/task-force/sc/index.html

Just Google 'ITU JTF'



The screenshot shows the ITU/WMO/UNESCO IOC Joint Task Force website. The browser address bar displays the URL: <http://www.itu.int/en/ITU-T/climatechange/task-force-sc/Pages/default.aspx>. The page features the ITU logo and the tagline "Committed to connecting the world". A search bar is located in the top right corner. The main navigation menu includes links to ITU, General Secretariat, Radiocommunication, Standardization, Development, ITU Telecom, and Membership. Below this, a secondary menu lists various resources like About ITU-T, Study Groups, Events, All Groups, Join ITU-T, Publications, Resources, Workshops, and Regional Presence. The main heading of the page is "ITU/WMO/UNESCO IOC Joint Task Force". A breadcrumb trail indicates the current location: "YOU ARE HERE > HOME > ITU-T > ITU-T AND CLIMATE CHANGE > ITU/WMO/UNESCO IOC TASK FORCE". The page content includes a section titled "Joint Task Force to investigate the potential of using submarine telecommunications cables for ocean and climate monitoring and disaster warning". This section describes a workshop organized by ITU, UNESCO IOC, and WMO on 8-9 September 2011, which resulted in the establishment of the Joint Task Force. To the right, there is a list of events, including the 3rd Workshop on Propelling a Pilot Project on Green Cables (Madrid, 19-20 September 2013), the 2nd Workshop on Submarine Communications Networks For Climate Monitoring and Disaster Warning (Paris, 20-21 September 2012), and the 1st Workshop on Submarine Cables Ocean/Climate Monitoring and Disaster Warning: Science, Engineering, Business and Law (Rome, 8-9 September 2011). The footer of the page displays the logos of UNESCO, IOC, ITU, and WMO, along with a "RESOURCES" link.

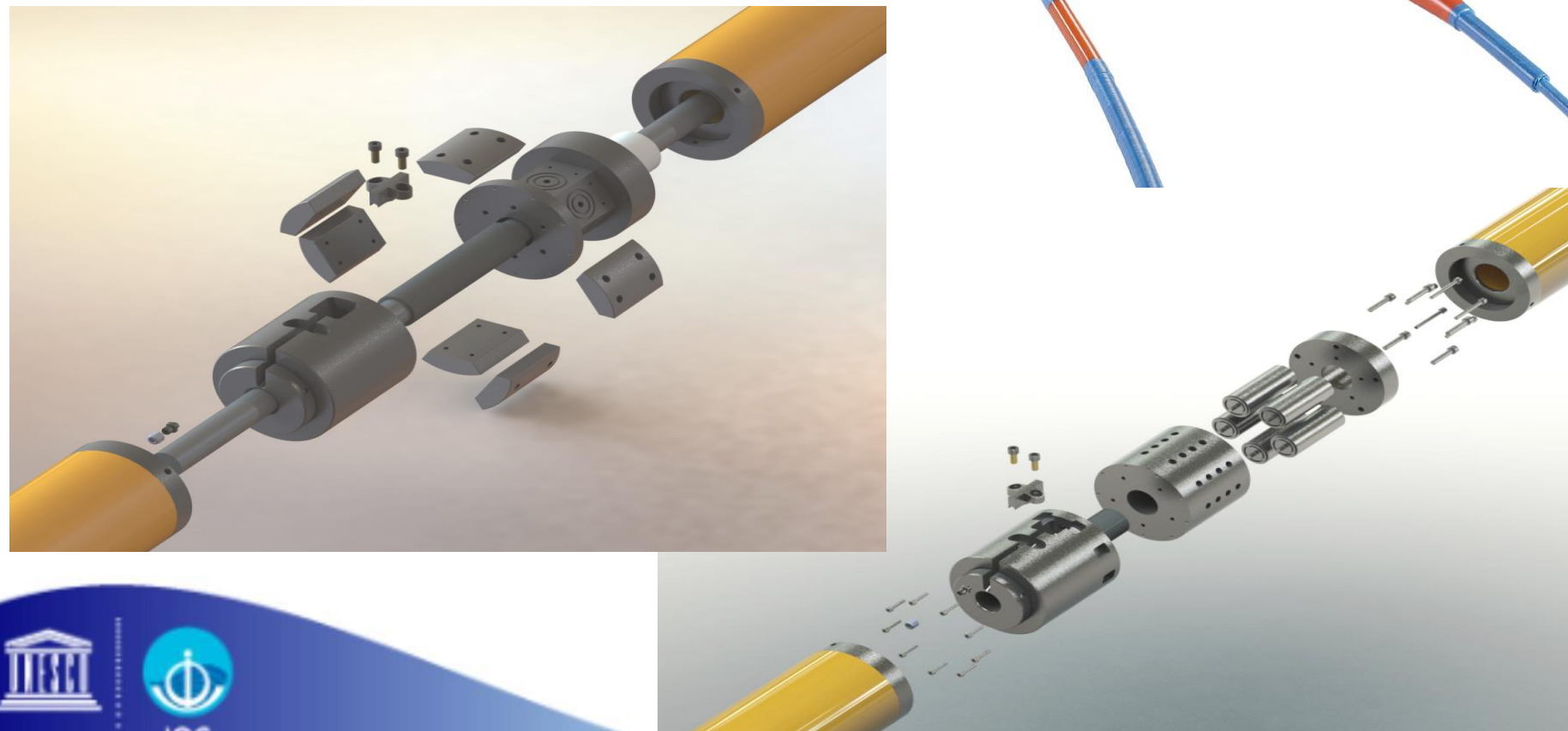
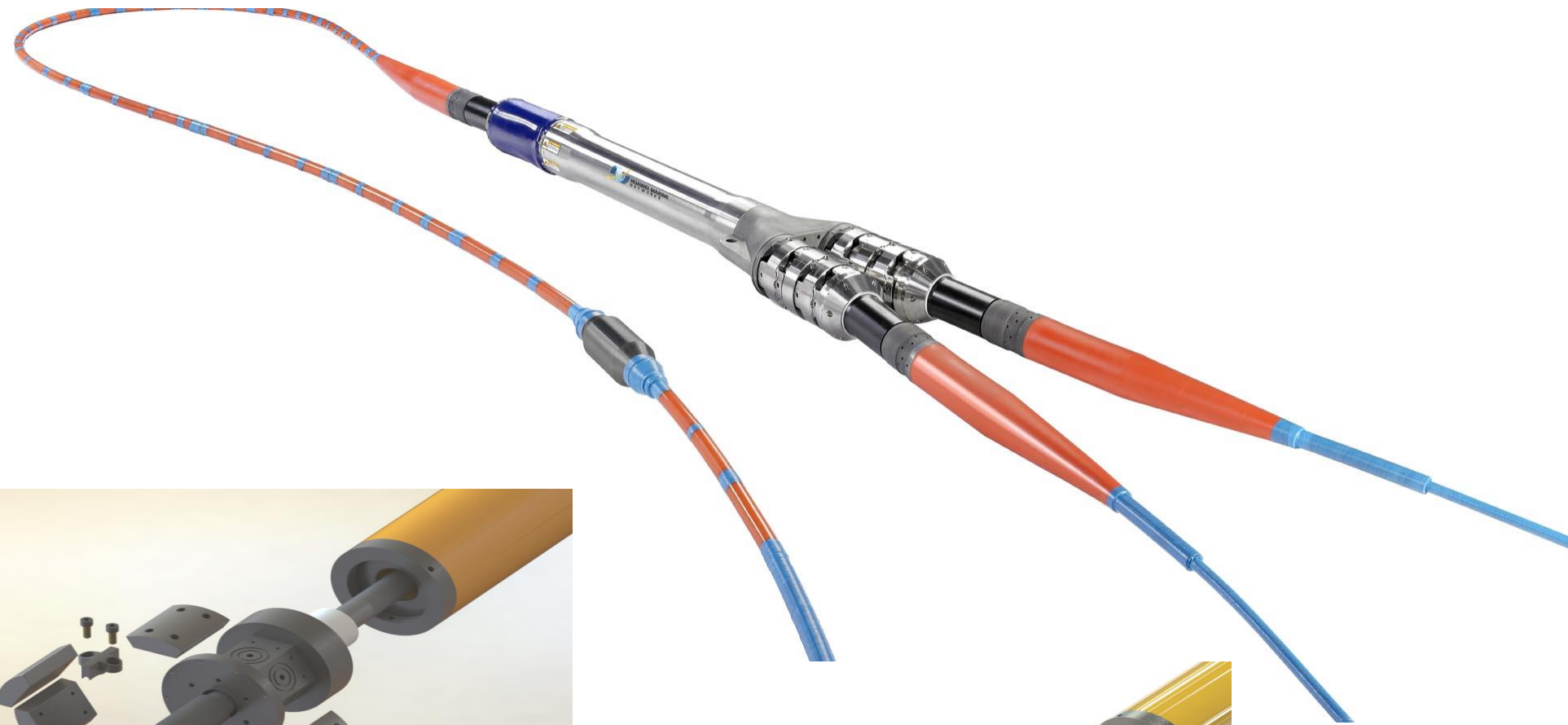
Progress since September 2011

- Establishment of 'Joint Task Force'
 - itu.int/ITU-T/climatechange/task-force/sc/index.html
 - Initial background reports by technical and legal experts
 - Meet by teleconference, ~yearly in person
 - 80 members of whom 10-20 are active
 - Sub committees
 - Science and society
 - Engineering
 - Business model
 - Legal
 - Publicity, awareness, marketing
 - Due diligence on engineering, business and legal issues has been completed
 - TESubCom 'Pacific Fibre' Project (currently on hold)
 - Buy-in from US (PMEL, Scripps) and Australia (BoM) for tsunametry

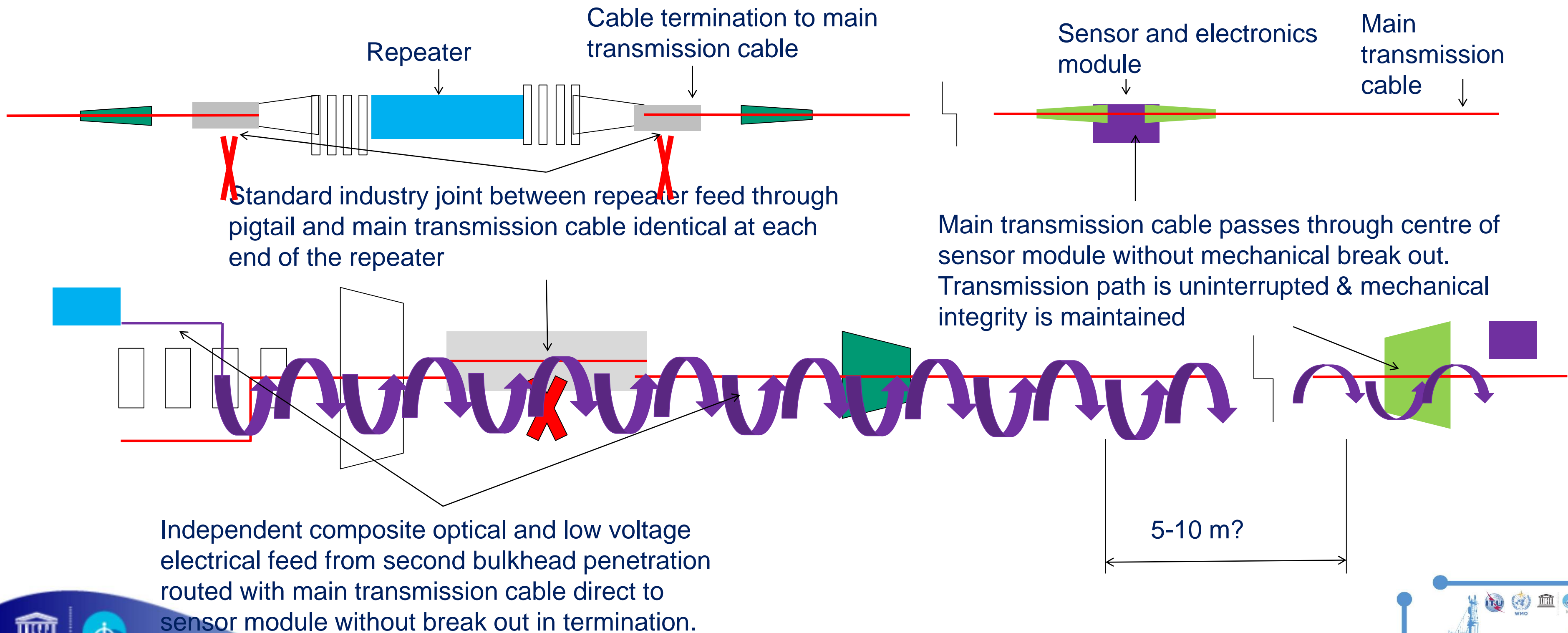


Sensor 'blister' (courtesy TESubCom)

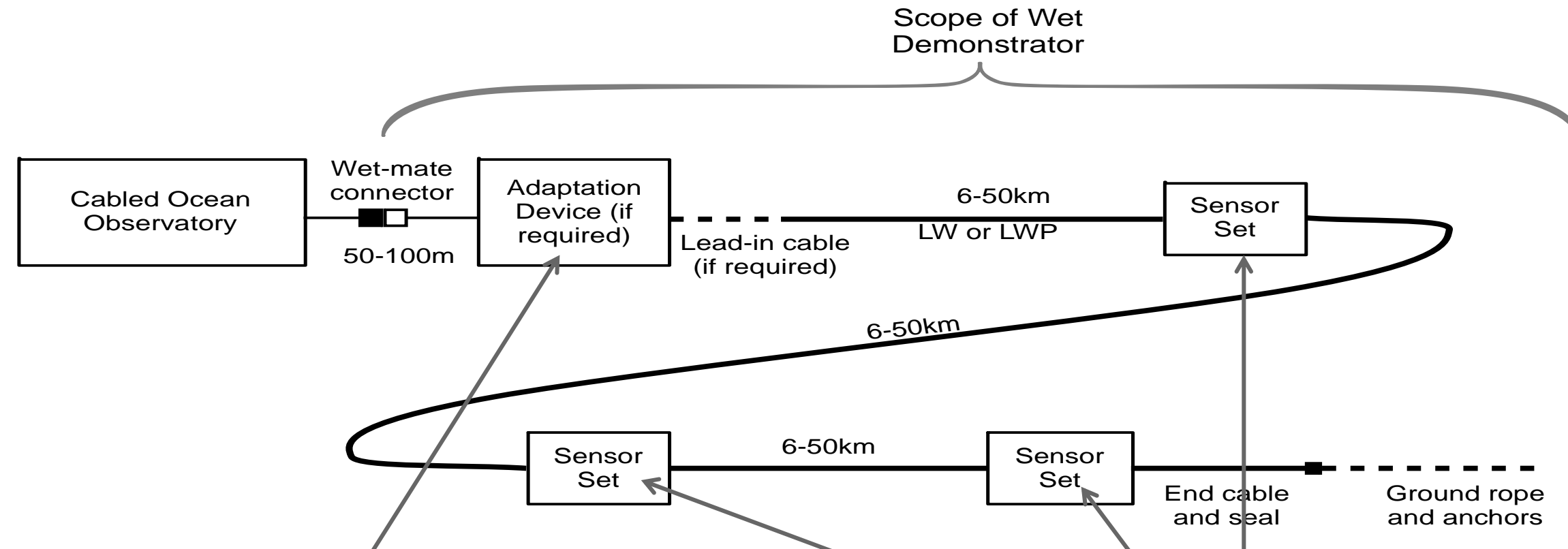
What a cable 'repeater' looks like



Sensor module to repeater connectivity



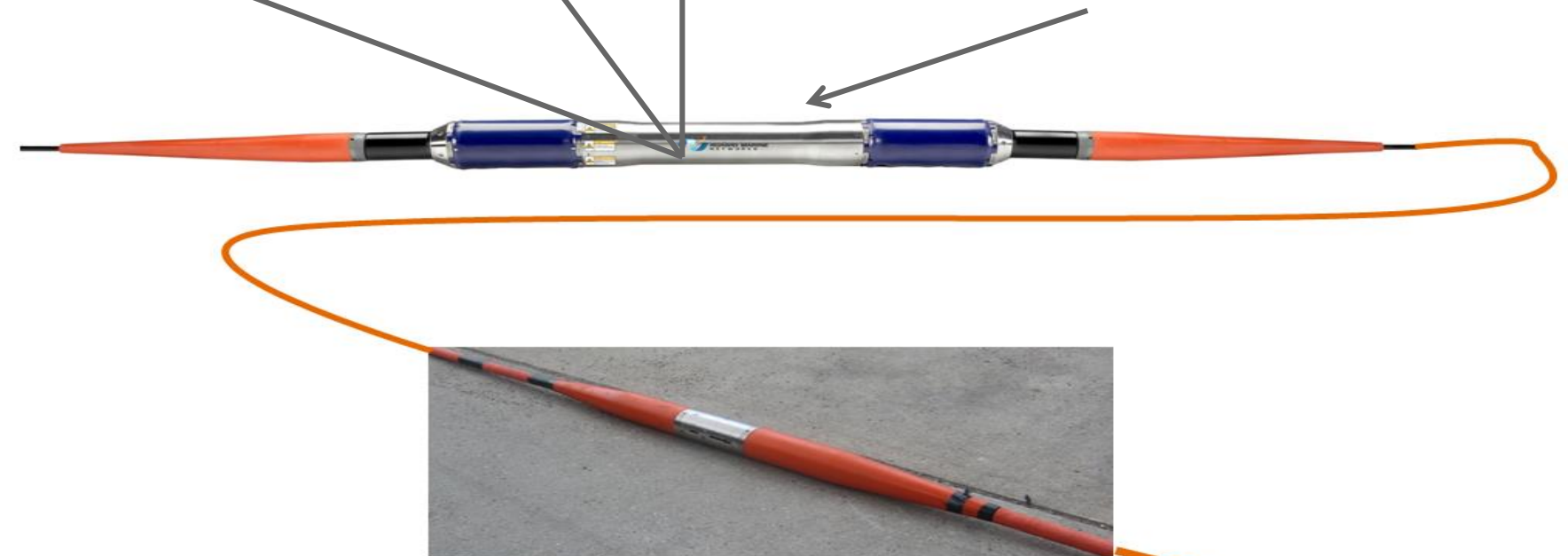
Proposal for Wet demonstrator.



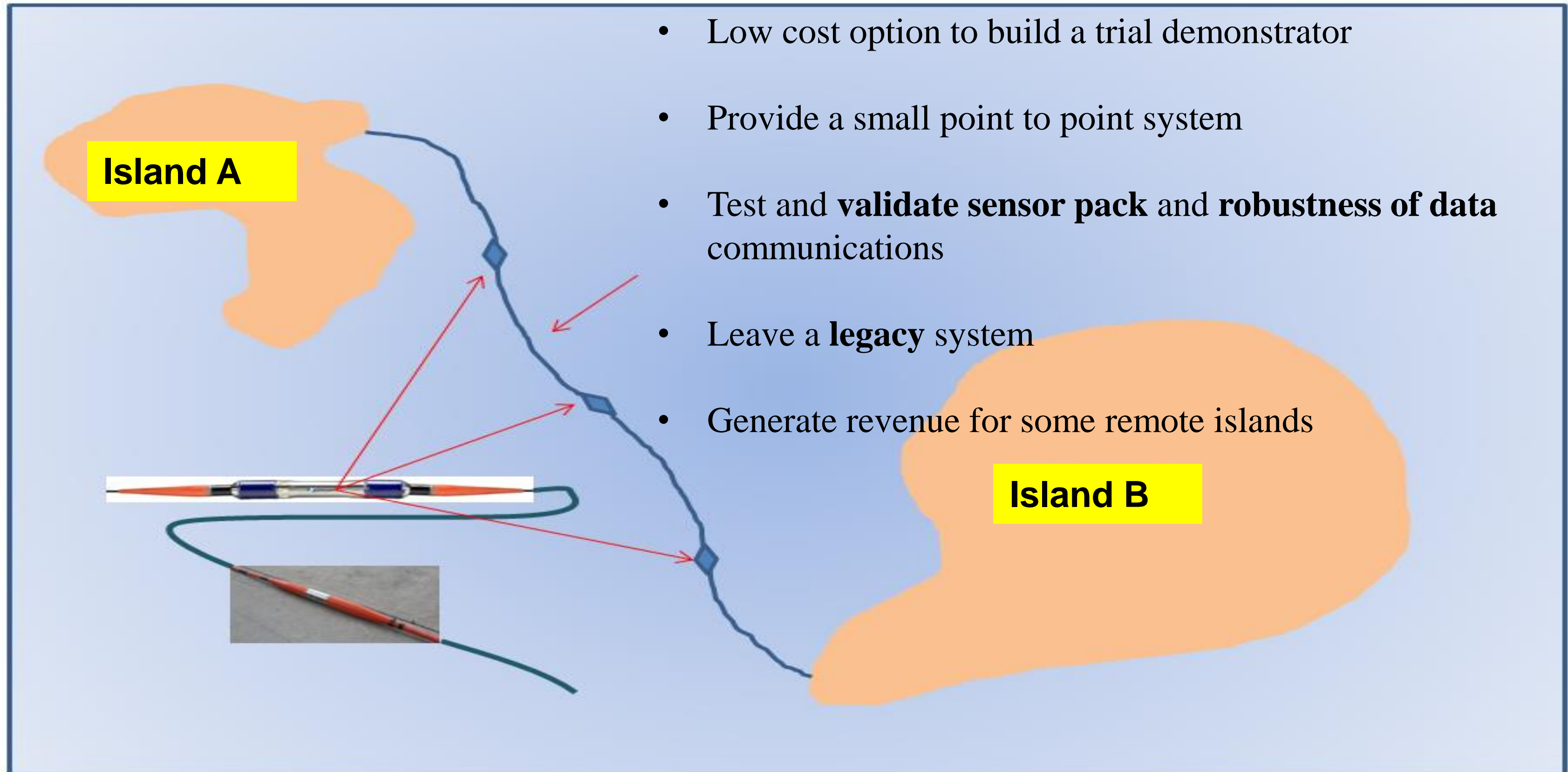
Dummy repeater housing to allow split out of separate composite power and optics feed to sensor set plus facilitate amplifier interface (ethernet) to transmission fibre



Wet mate hybrid or separate power optical penetrators leading to a jumper set to connect to science observatory



Potential case for discussion



Overarching issues

- Keep it simple to build confidence in a sceptical industry!
- Certifying long-term reliability
 - Little history for >10 year deployments
- Long-term drift
 - How to characterise
 - Not important for tsunami detection
 - Important for climate monitoring
- Integration within commercial cable
 - Must not have any risk of disrupting core mission
 - Due diligence already undertaken (by TESubCom....)
 - Legal restrictions linked to Marine Scientific Research



More Recent Progress

- ITU issued RFI for Wet Demo, Dec 2016 – good response, budgetary quotes next
- RFP for New Caledonia to Fiji cable issued by OPT
- Tsunami Warning, Education and Research Act of 2017
- Other projects with possible synergies:
 - Deep Ocean Observing Strategy
 - International Seabed Authority
- Over-arching need to increase visibility at highest levels



OPT-New Caledonia system to Fiji

- RFP issued December 2016 with SMART option
- Nearly ideal for pilot:
 - High earthquake/tsunami threat, oceanography
 - Project wants SMART for societal benefit
 - Modest scale (~20 repeaters)
 - Between friendly countries
 - Fewer permitting and legal issues
 - Telecom system single government funded
 - Plausible to raise incremental funding required
 - DART buoys here extremely expensive to maintain (1000 km N and E, off map)
 - Time frame reasonable
 - Demonstrate complete capability - integration into repeater power+comms, interface, external sensor package



US Tsunami Warning, Education and Research Act 2017

- 18 April 2017 became Public Law No: 115-25
 - Authorized activities ... “Development of practical applications ... including the integration of tsunami sensors into Federal and commercial submarine telecommunication cables if practicable.”
 - Responsibilities ... “consider appropriate and cost effective solutions to mitigate the impact of tsunami, including ... integration of tsunami sensors into commercial and Federal telecommunications cables, ... “
- ... Will positively influence other agencies:
FCC, USGS, NSF, BOEM, DoD,

Monday, October 19, 2015

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Senate Unanimously Passes Tsunami Act

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Posted on October 7, 2015

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by Big Island Now Staff

The [Tsunami Warning, Education, and Research Act of 2015](#), introduced by United States Senators Brian Schatz, Maria Cantwell, and Dan Sullivan, has unanimously passed the Senate.

United States Senator Brian Schatz. U.S. Senate photo.

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16:45 19/10/2015

Take home message...

- Science case very strong: will deliver major societal benefits
- Engineering, commercial and legal challenges can all be solved
- Cable industry is still very cautious
- Over-arching need to increase visibility of initiative at highest levels



All issues can be overcome: cables are the future!



TAT-1, Oban, Scotland, 1956

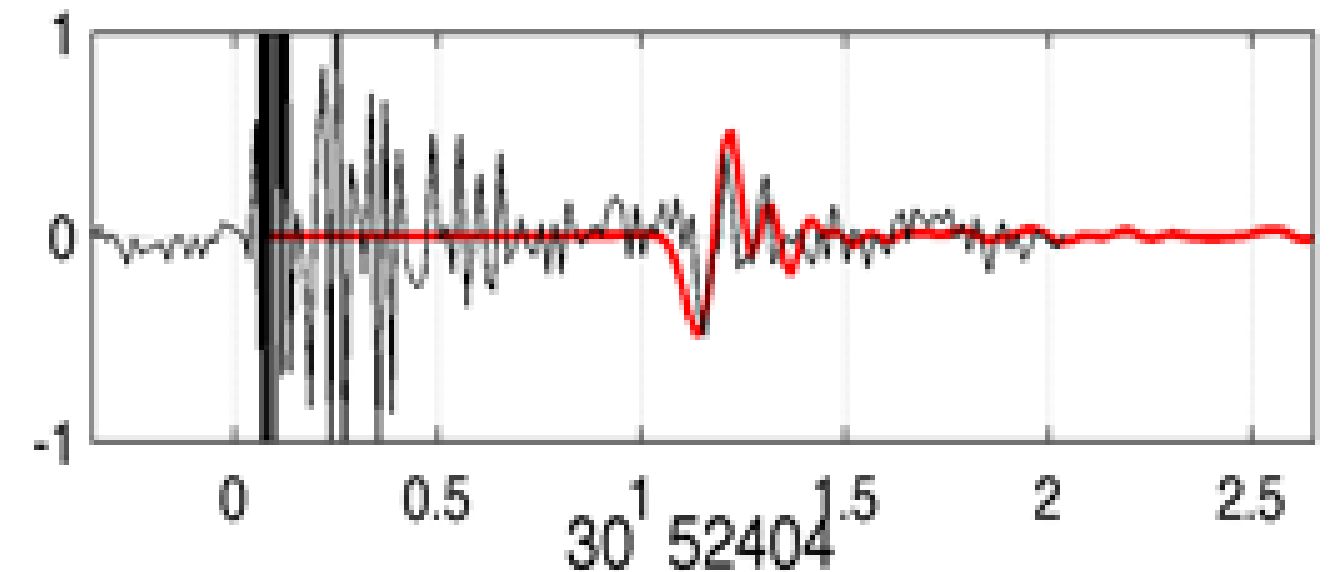
P and T for climate change

- P is integrated density of water column and yields
 - Better estimates of ocean circulation at seasonal to decadal timescales
 - Validation of satellite estimates
- T yields
 - Sea level rise through bulk ocean warming
 - Deep ocean heat storage (present measurements very sparse)
 - Dynamics (deep ocean 'weather') if measurements frequent enough
- Issues
 - Optimal spacing
 - Sensor stability over decadal timescales
 - Sensor reliability

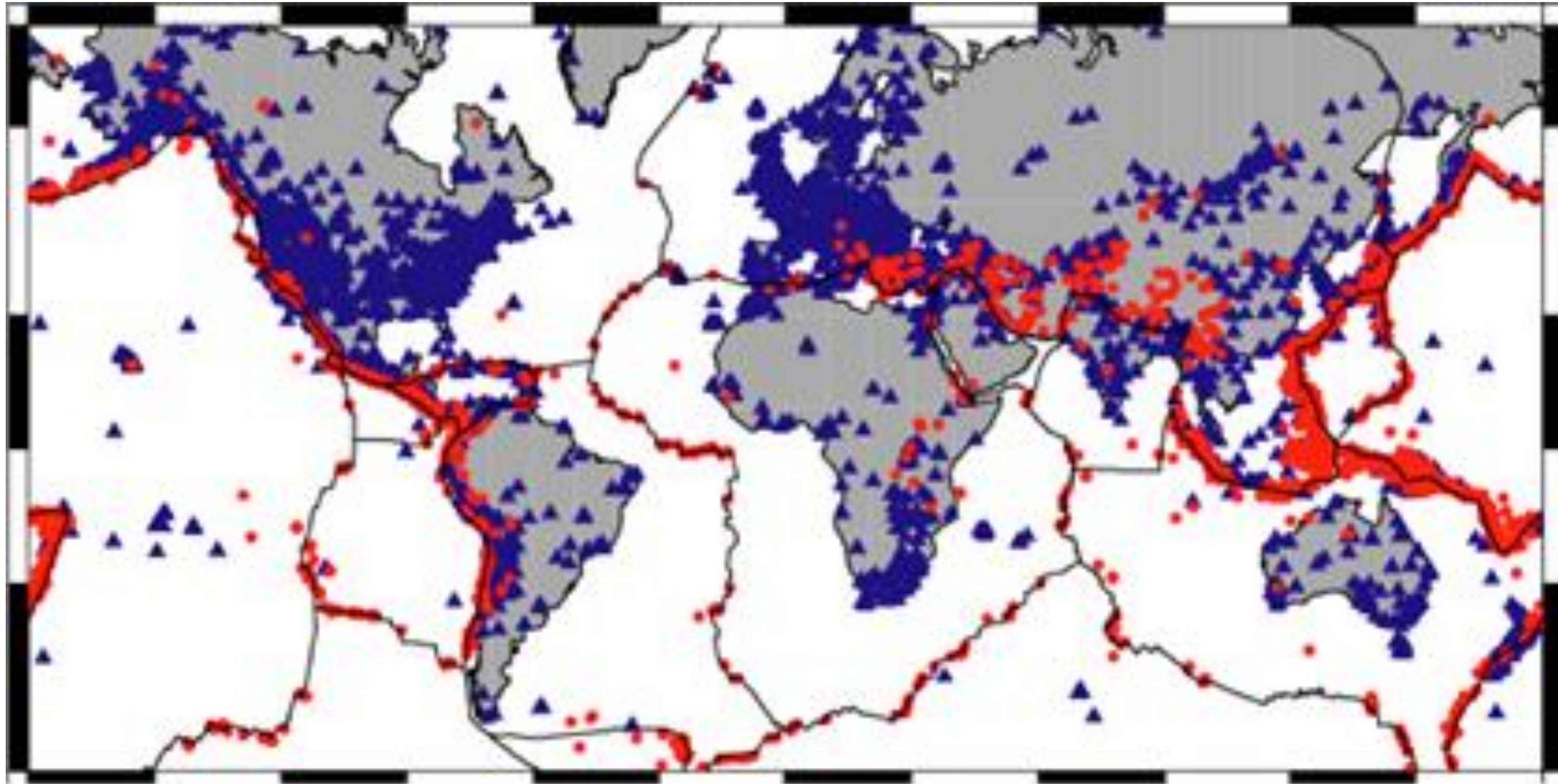


P for tsunami detection

- Better than seismology on its own
 - Detects actual passage of tsunami wave
 - Not all earthquakes generate tsunamis
 - Not all tsunamis are generated by earthquakes
 - Landslides
 - Meteorological disturbances
- Cabled sensors much less vandal-prone than existing network
- Issues
 - Aliasing of seismic and tsunami signals
 - Especially in near field
 - Mitigated by much higher frequency sampling



Seismology for earthquakes and tsunamis



Blue: stations Red: sources

Seismology for earthquakes and tsunamis

- Most major earthquakes occur beneath the sea
- Present marine seismic network is very sparse
 - Need better distribution to improve understanding of earth's interior
 - Dual use for tsunami warning
- Issues
 - Accelerometer, hydrophone or P?
 - Timing accuracy
 - Are MEMS sensors good enough?



Overarching issues

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