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Visualization System for the Positioning of Sunken Vessels Using Underwater Acoustic Devices

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GIS
Wireless sensor

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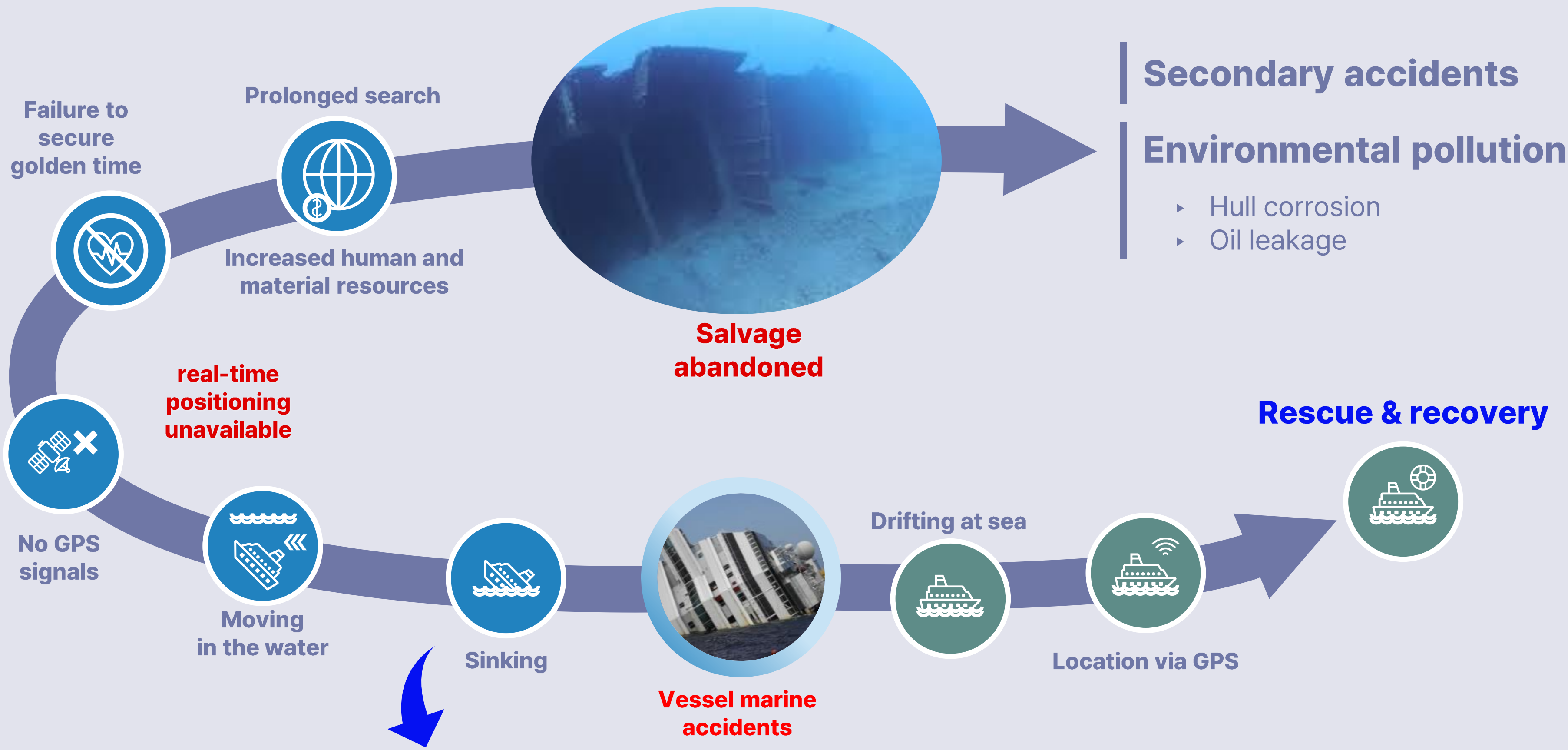
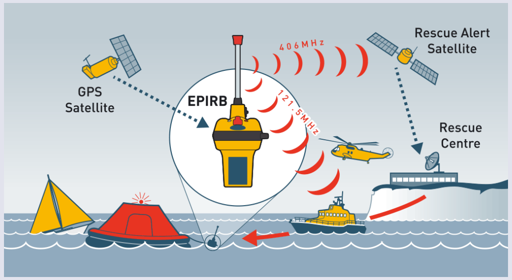


Emergency Position Indication Radio Beacon (EPIRB)

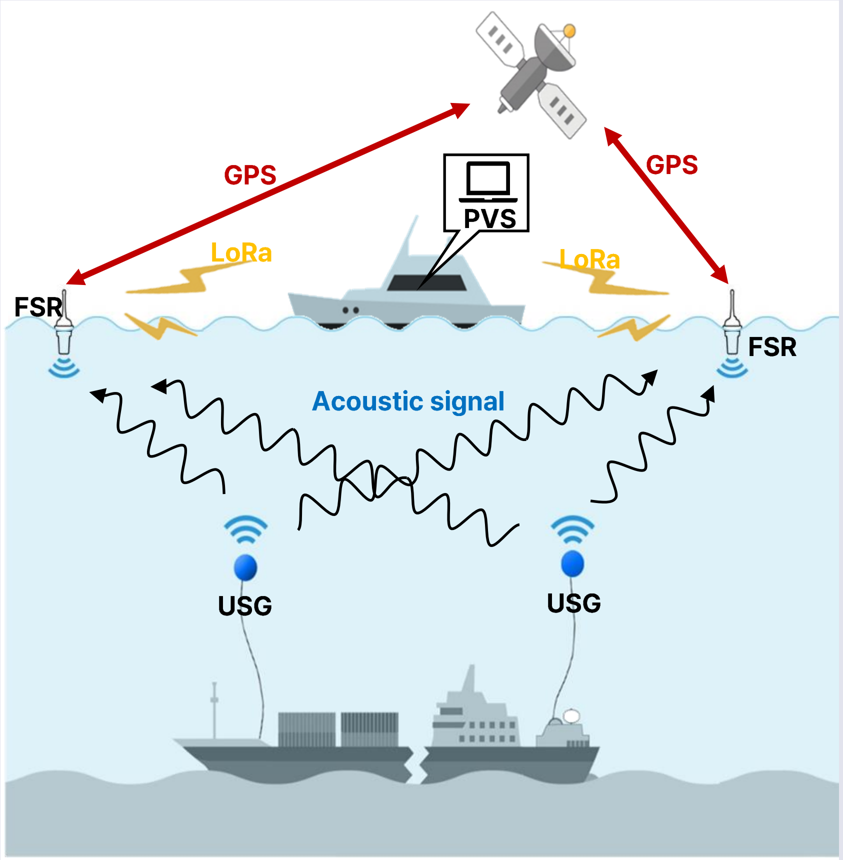


INTRODUCTION

SVPIS

Sunken **V**essel **P**osition **I**dentification **S**ystem

Real-time tracking System
for sunken vessels

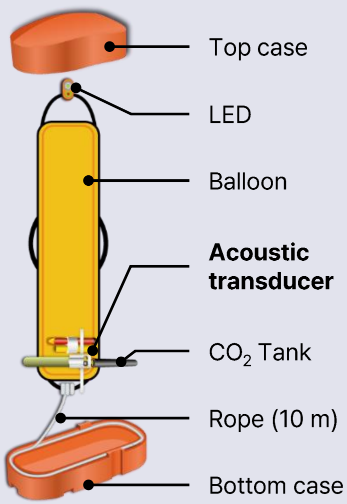


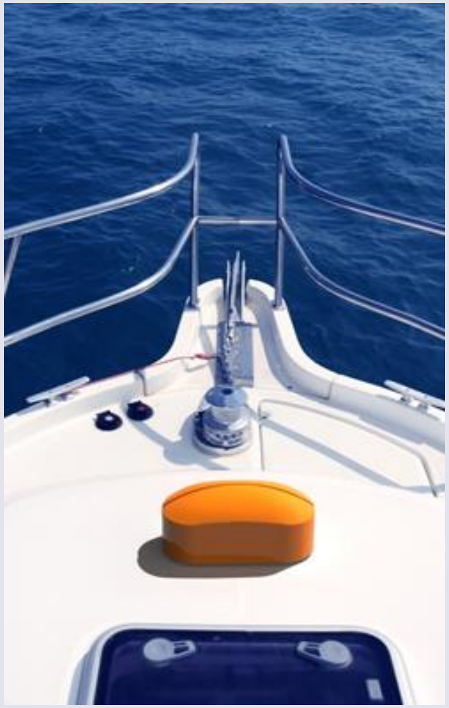
Components

- Underwater Signal **Generator** (USG)
- Floating Signal **Receiver** (FSR)
- **Positioning** & **Visualization** System (PVS)

Reduce searching time
to improve rescue efficiency
and **minimize loss of life and property**

Components of SVPIS





Underwater Signal Generator (USG)

- Operating procedures:
  1. Automatically deployed by water pressure
  2. Rises 10m in the water (connected to hull with cable)
  3. Generate sound signals and flashing LED lights
- Continuous operation time: 36 months

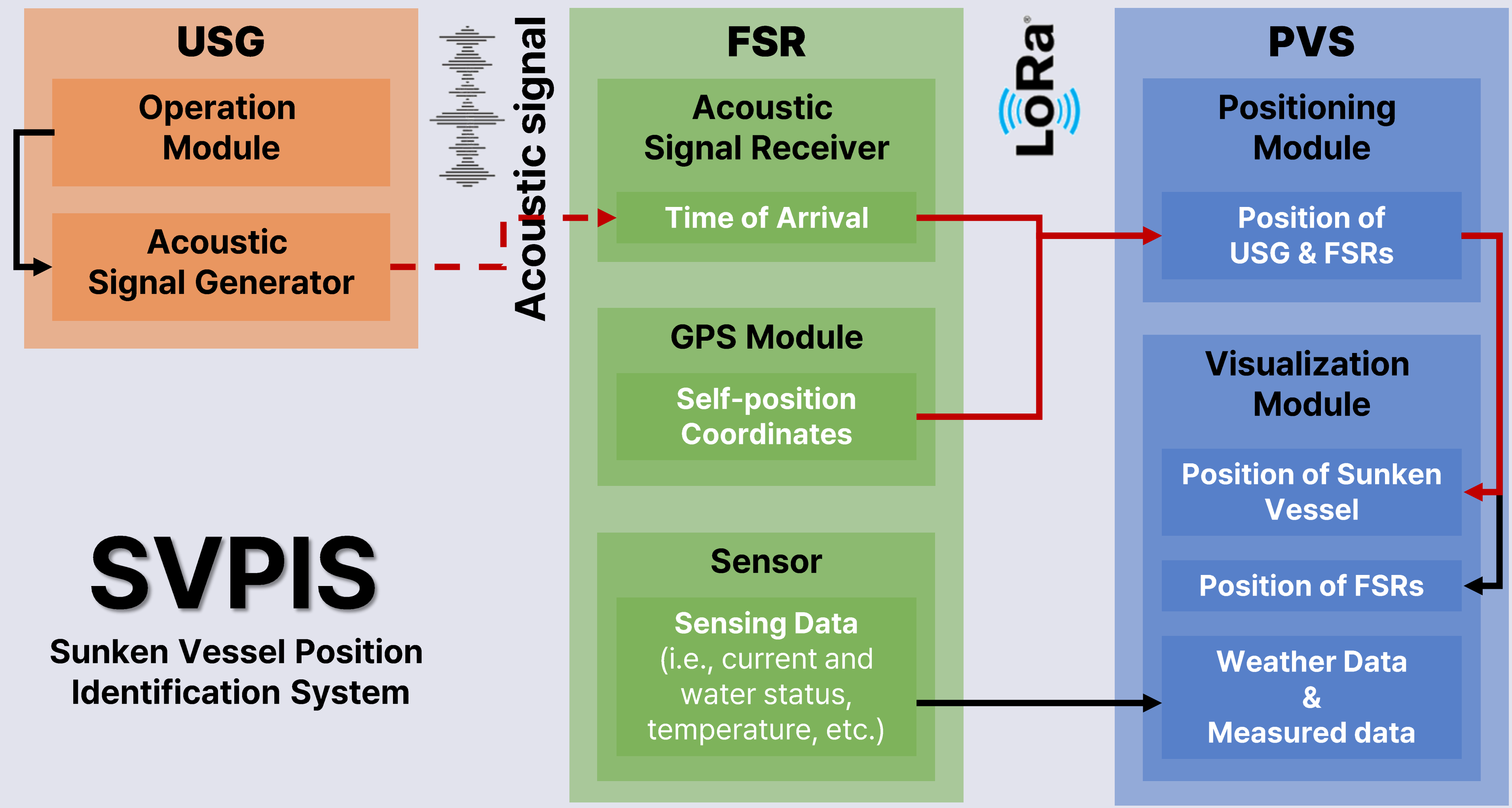
Floating Signal Receiver(FSR)

- Operating Procedures:
  1. Devices synchronization for four FSRs in a group
  2. Deploy in any groups of FSR on the water surface
  3. Receiving acoustic signals from USG and getting self location(GPS)
  4. Send TOA and GPS coordinates to PVS
- Can be configured in various forms depending on specific requirements
  - Sensors can be included for measuring (temperature, current, water status, etc.)

Positioning & Visualization System (PVS)

- Operating Procedures:
  1. Registering devices before FSR deployment
  2. Positioning sunken vessel(USG) through receiving data from FSRs
  3. Displaying location of USG, FSR and PVS
  4. Displaying environmental information that affects rescue works (weather and maritime conditions)

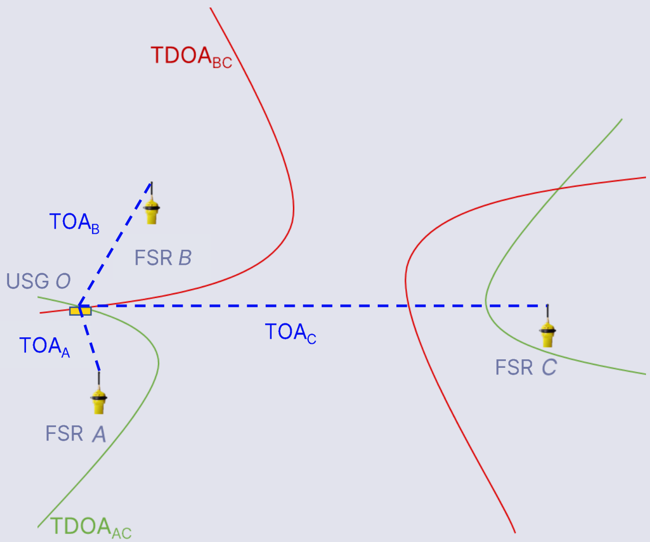
Design Concept of SVPIS



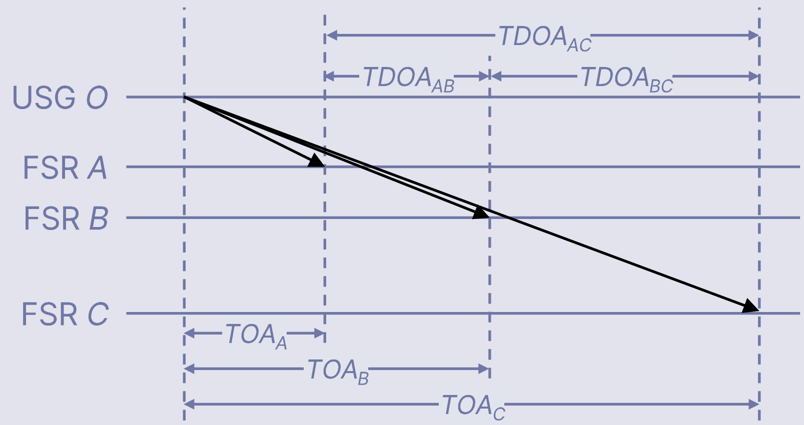
Positioning through TDOA

TDOA: Time Difference of Arrival

2-dimensional positioning through TDOA (using 3 FSRs)



Transmission and Reception of TDOA positioning



Least Square algorithm

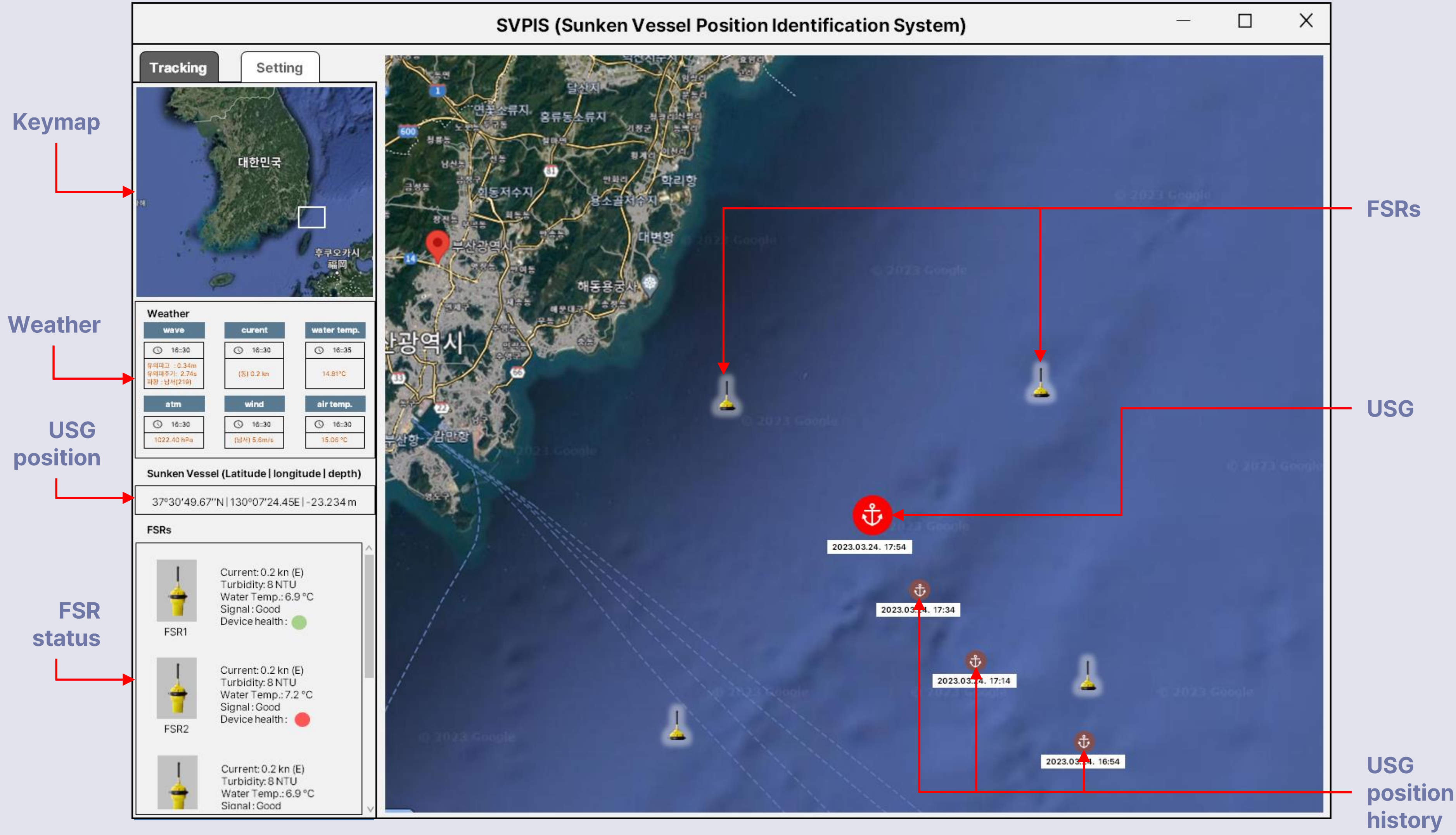
- The easiest and cheapest solution
- Highly nonlinear coupled equation
  → improve solutions are proposed
  (Bucher, Bard, Smith, Chan-Ho, etc.)

$$2\begin{bmatrix} x_2' & y_2' & \frac{r_{2,1}}{2} \\ \vdots & \vdots & \vdots \\ x_n' & y_n' & \frac{r_{n,1}}{2} \end{bmatrix} \begin{bmatrix} x \\ y \\ r_1 \end{bmatrix} = \begin{bmatrix} k_2' - r_{2,1}^2 \\ \vdots \\ k_2' - r_{2,1}^2 \end{bmatrix} \Rightarrow 2\mathbf{Ap} = \mathbf{k}$$

$$(x_n' = x_n - x_1, \qquad r_{n,1} = r_n - r_1)$$

$$\therefore \mathbf{P} = \frac{1}{2}(\mathbf{A}^T\mathbf{A})^{-1}\mathbf{A}^T\mathbf{k}$$

VISUALIZATION SYSTEM



Measured data from sensors of FSRs
Available Electronic Navigational Chart, satellite maps

CONCLUSION

SVPIS = Underwater Positioning System through Acoustic Signal

Real-time location tracking
of sunken vessels

Minimizing resource
(human and material) inputs for underwater search

Maximizing the efficiency
of underwater search and rescue operations

Prevent
marine pollution and secondary accidents

Future Works

Challenges (Ensure underwater positioning accuracy)

- Noise in underwater acoustic signals
  (marine life, water turbulence, sea surface reflection, man-made objects, etc.)
  → **Noise filtering Method**(matched filtering, adaptive filtering, wavelet denoising, etc.)
  → Deep-learning
- Strict time synchronization between FSRs
  → Master clock approach
  → Ping synchronization method
  → Hybrid method

Possible applications

- Applicable to all modes of transport over water
  → Contribute to not only ships
  → But all underwater vehicles, including helicopters, drones, and submarines.
- Expanding applications through **miniaturization of underwater signal generator**
  → Tracking the location of underwater rescuers
  → Underwater and marine leisure sports

Thanks for YOUR attention

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