AI-Powered NExt-Generation RobotiCs for InSpection and Maintenance (AI-NECS)

Incorporating Lessons Learned from Freelander-HERO Development and Operational Experience

Poramate Manoonpong (VISTEC, IST)

VISTEC 10 YEARS

PTTEP

Address: Pillar 1 “Drive Value”

Technology Focus Areas

- *Most confidential* -

PTTEP

PTTEP’s Pain Points

Drive Value

Improve operations and reduce unit cost for core E&P operations

Decarbonize

Reduce carbon emission thru CCUS, renewables & offsetting technologies

Diversify

Enabler for low carbon & future energy businesses

Focus Area	Problem Statement
Contaminant Removal	*High OPEX cost for absorbance for As removal which better than existing absorbent required changing every 1.5 – 2 years*
Operation supports	*High amount of sand found in multiple separators which required total shutdown for sand removal every 2-4 years* *Finding technology for cleaning non pigable pipeline.*
Maintenance and Inspection	Seeking new technology to predict integrity of aging platform with low effort (Not require internal inspection, difficult accessibility area)

Focus Area	Problem Statement
Carbon Capture Utilization & Storage	*Traditional carbon capture methods are inefficient and costly, exceeding 40 USD/tonCO_2, and require technology to utilize and store the captured CO_2.*
Flaring and Venting Reduction	*High CO_2 emission from flaring. Seeking technology for flare gas utilization.*
Renewable Integration & Energy Efficiency	*High CO_2 emissions from traditional combustion engines, such as gas turbines and diesel engines.*
GHG Monitoring, Leak Detection	*Seeking cost-efficient, unmanned technology to monitor GHG and detect leaks in confined spaces.*

Focus Area	Problem Statement
Hydrogen Production	*High cost and low efficiency of green H_2 production* *High cost and low efficiency of blue H_2 production*
Hydrogen Carrier	*High cost of hydrogen transportation (ammonia cracking, hydrogen carriers)*
Renewable Energy *(Offshore Wind, etc.)*	*Seeking innovative wind turbine technology suitable for very low wind speed (Thailand)*

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Technology Focus Areas

- Most confidential -

PTTEP

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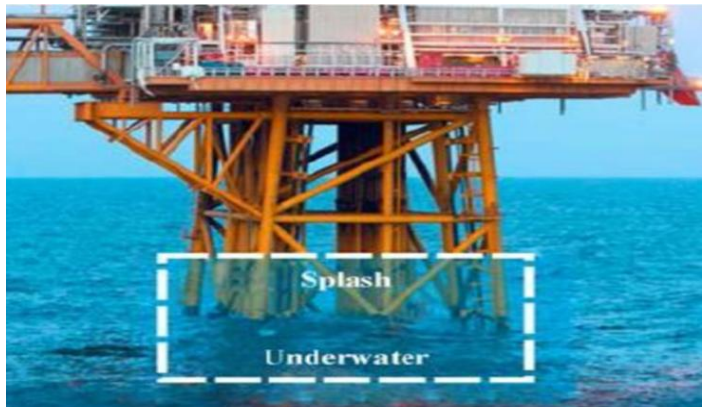
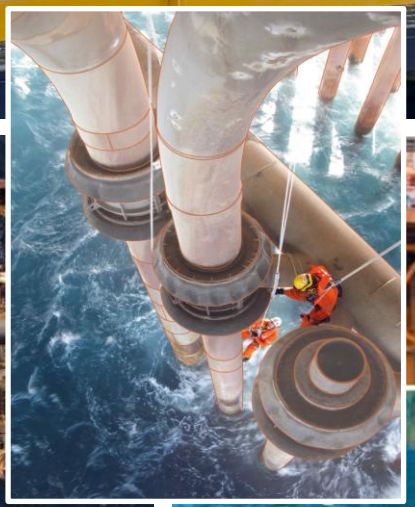
Renewable Energy *(Offshore Wind, etc.)*	*Seeking innovative wind turbine technology suitable for very low wind speed (Thailand)*

Maintenance and Inspection	**2. Aging facility platform**	Seeking new technology to predict integrity of aging platform with low effort (Not require internal inspection, difficult accessibility area)	❑ Reduce cost and manpower for inspection

Inspection Tasks



Inspection Tasks



Inspection Robotics Technology Development

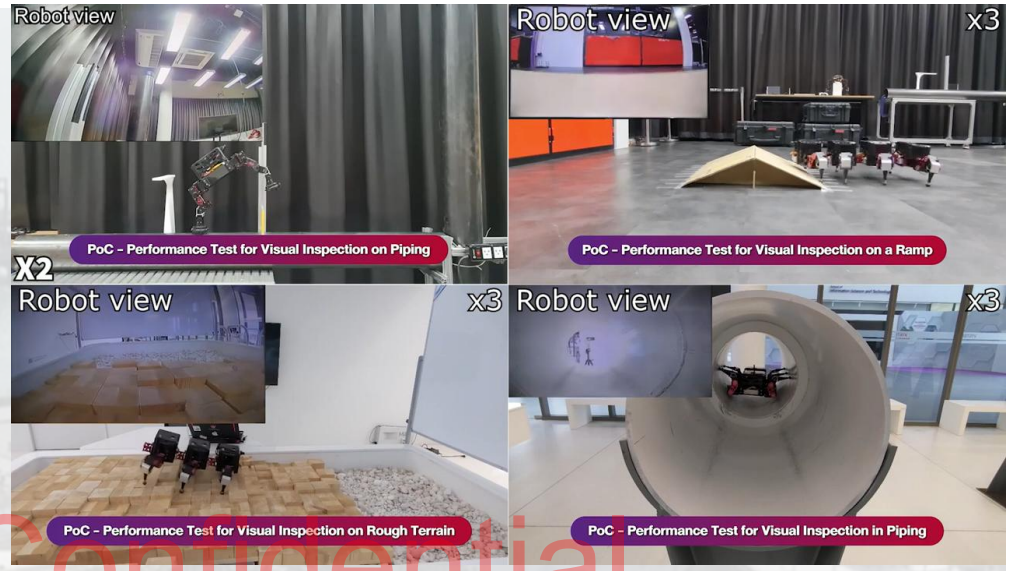
F-TECH:
6 x Papers
2 x Invention Patent Filing
1 x Innovation Award 2023

F-TECH

(Freelander)

HERO

(Freelander: HERO)



VISTEC PTTEP

Magnetic Testing (MT)

HERO:
2 x Papers
1 x Invention Patent Filing

Inspection Robotics Technology Development

F-TECH

(Freelander)

HERO

(Freelander: HERO)

- **Non-Destructive Testing (NDT)**:
  - Magnetic Testing (MT),
  - Ultrasonic thickness measurement (UTM/possible))
- **Visual Inspection**
- **Vessels / Tanks / Pipes** (static equipment inspection onshore)

Inspection Robots

COMPETITOR

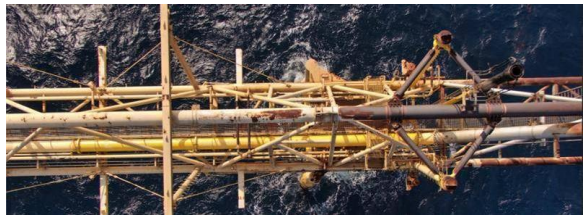
Adaptive Multifunctional Robot for maintenance and inspection

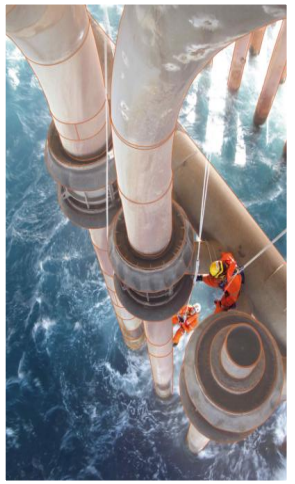
Robot (company)	(PTTEP & VISTEC)
Visual Inspection	★★★
NDT Inspection	★★★ (MT)
Payload	★★★ (15 kg)
Wheel Alignment (Curve Surface)	★★★ (roll/pitch axes)
Discontinuous Surface	★★★

Extending the current robotics tech towards

AI-Powered NExt-Generation RobotiCs for InSpection and Maintenance (AI-NECS)

- To perform inspection in narrow space/gap
- To adaptively move on non ferromagnetic surface
- To adaptively climb on complex (non ferromagnetic) pipe structures
- (Optional) To inspect at splash zone and subsea locations





F-TECH

(Freelander)

HERO

(Freelander: HERO)

AI-NECS

VISTEC 10 YEARS

PTTEP

(PTTEP & VISTEC)

★★★

★★★

(MT)

★★★

(15 kg)

★★★

(roll/pitch axes)

★★★

AI-
NECS

AI-Powered NExt-Generation RobotiCs for InSpection and Maintenance (AI-NECS)

Task 1: Bio-inspired hybrid rigid-soft extendable, floatable link/arm (*To perform inspection in narrow space/gap*)

Task 2: Adaptive joint compliant control *(To adaptively move on non ferromagnetic surface)*

Task 3: Intelligent multi-segmented body control *(To adaptively climb on complex "non ferromagnetic" pipe structures)*

Task 4: System integration and research translation to a centipede robot "CENTIPOT" *(To navigate on non ferromagnetic structures)*

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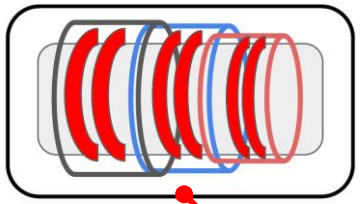
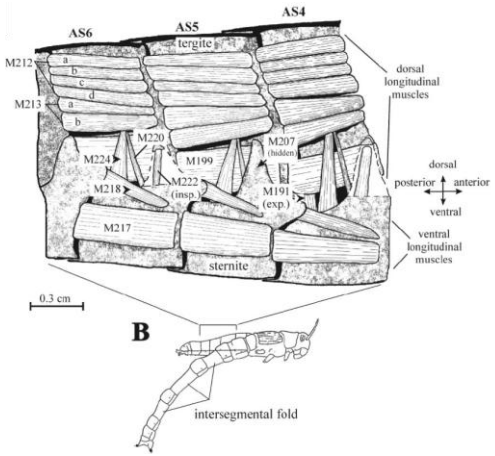
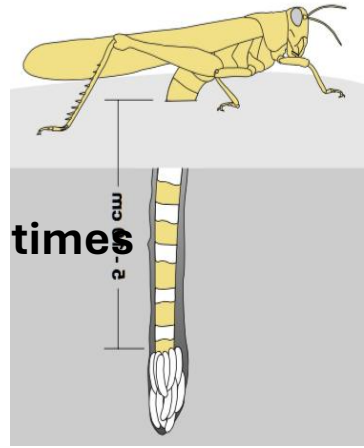




Das, R., Ayali, A., Guershon, M., Ibraheem, A., Perlson, E. and Pinchasik, B.E., 2022. The biomechanics of ultra-stretchable nerves. Iscience, 25(11).



"Female locust can extend her body to 2-3 times when laying eggs in the ground, without causing damage"

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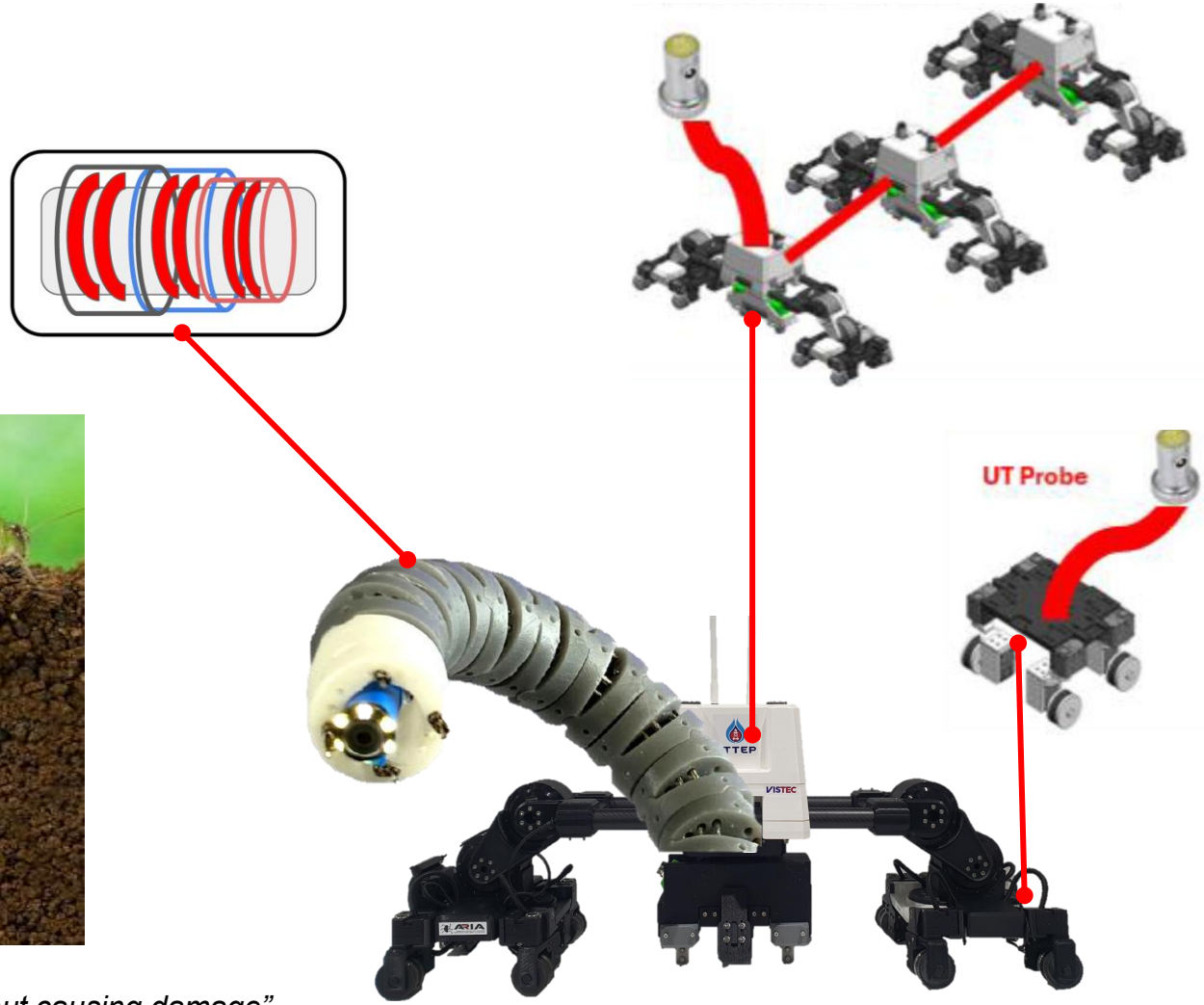

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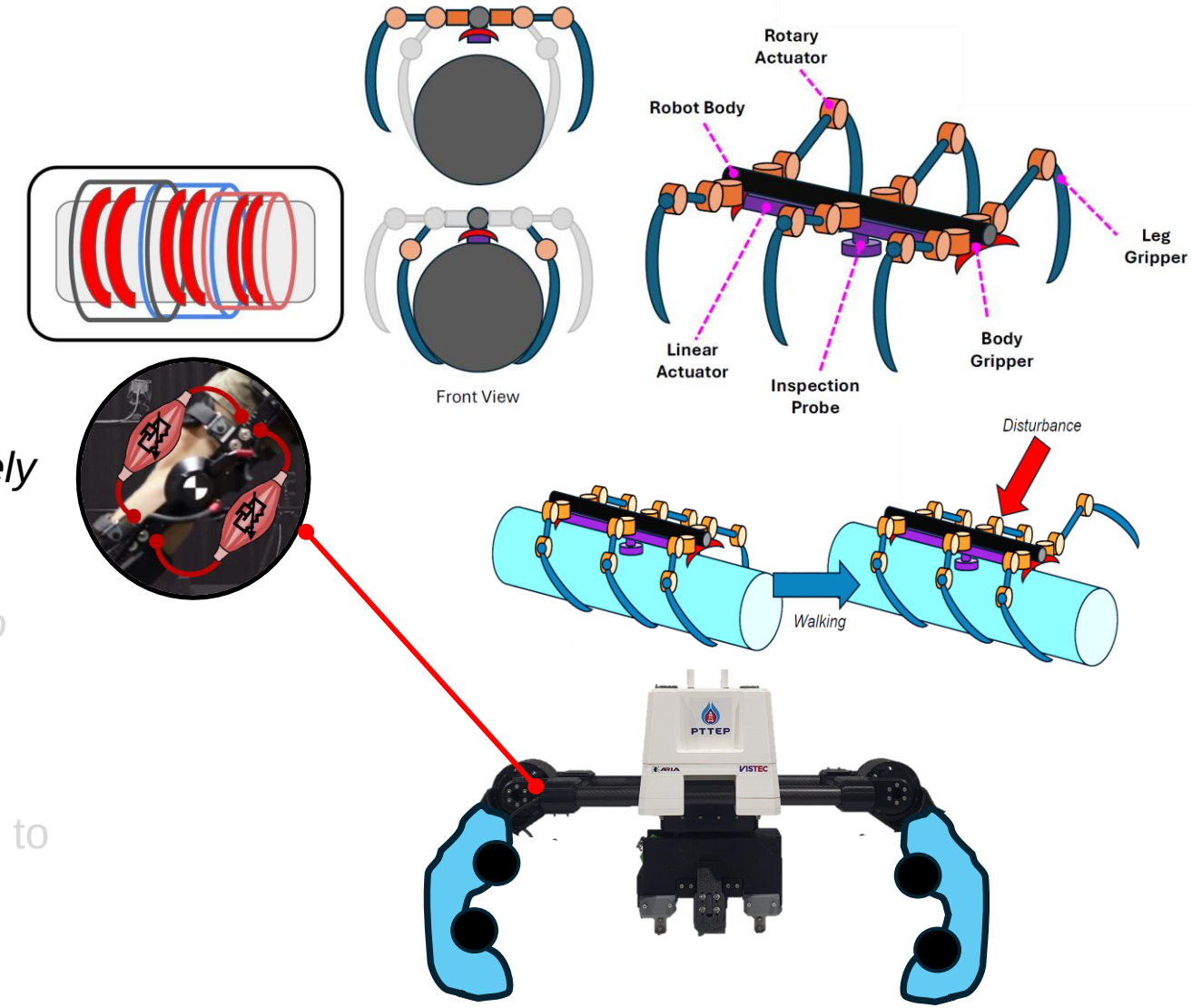

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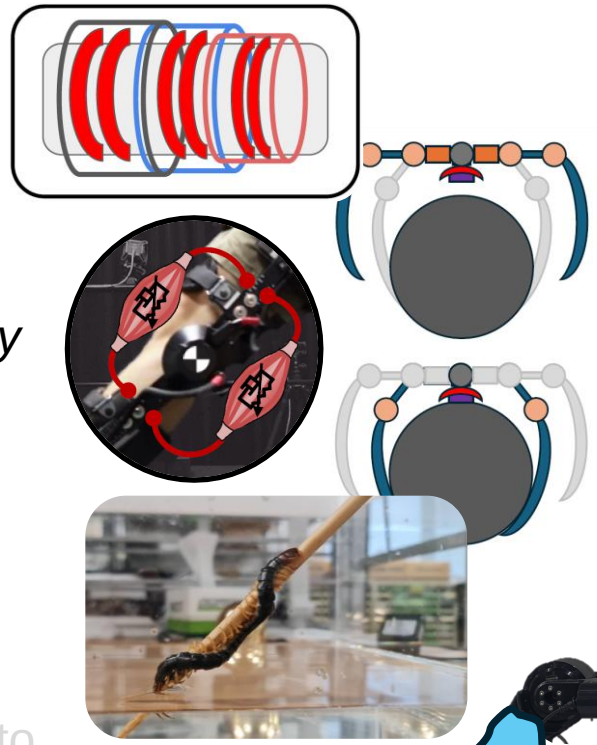

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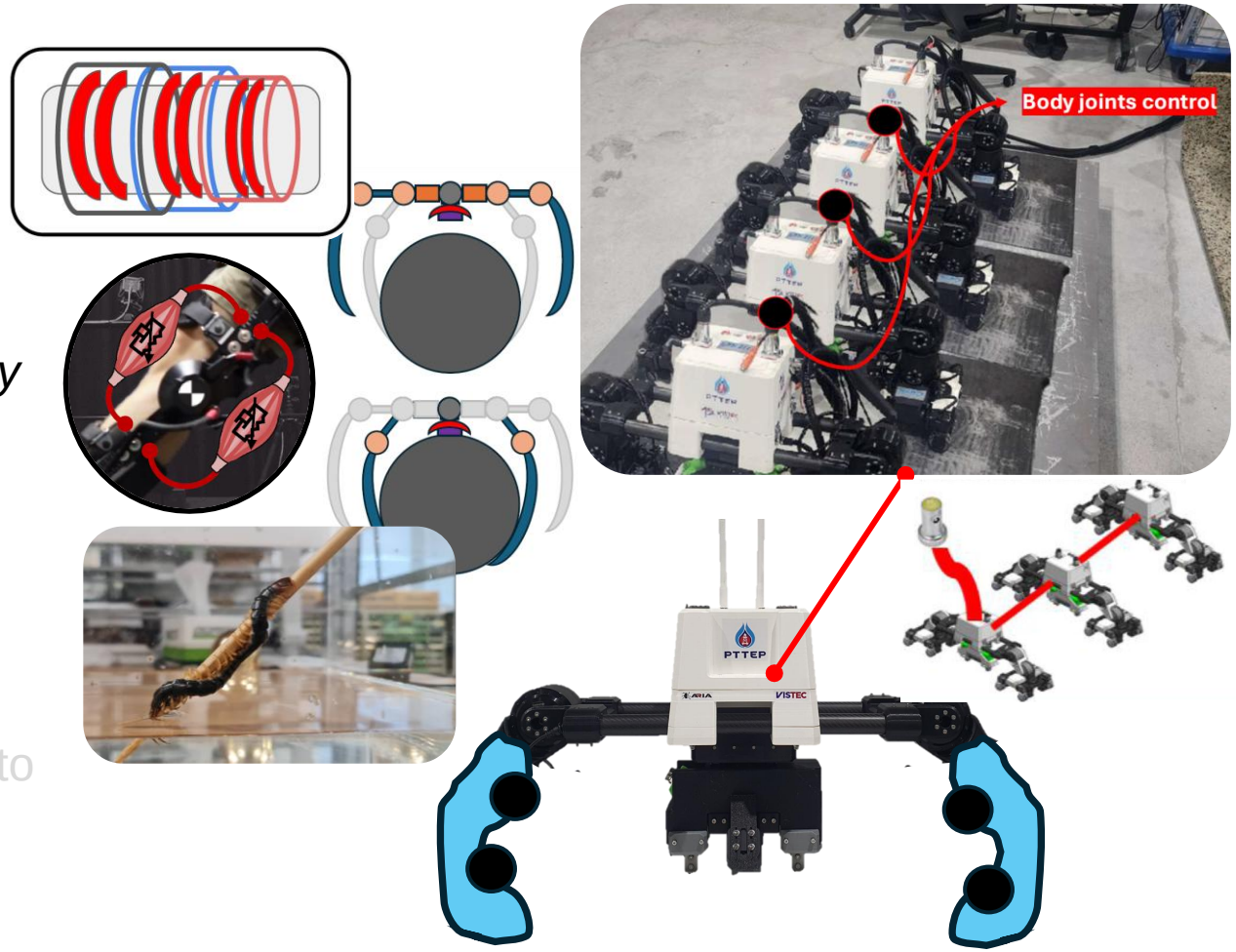

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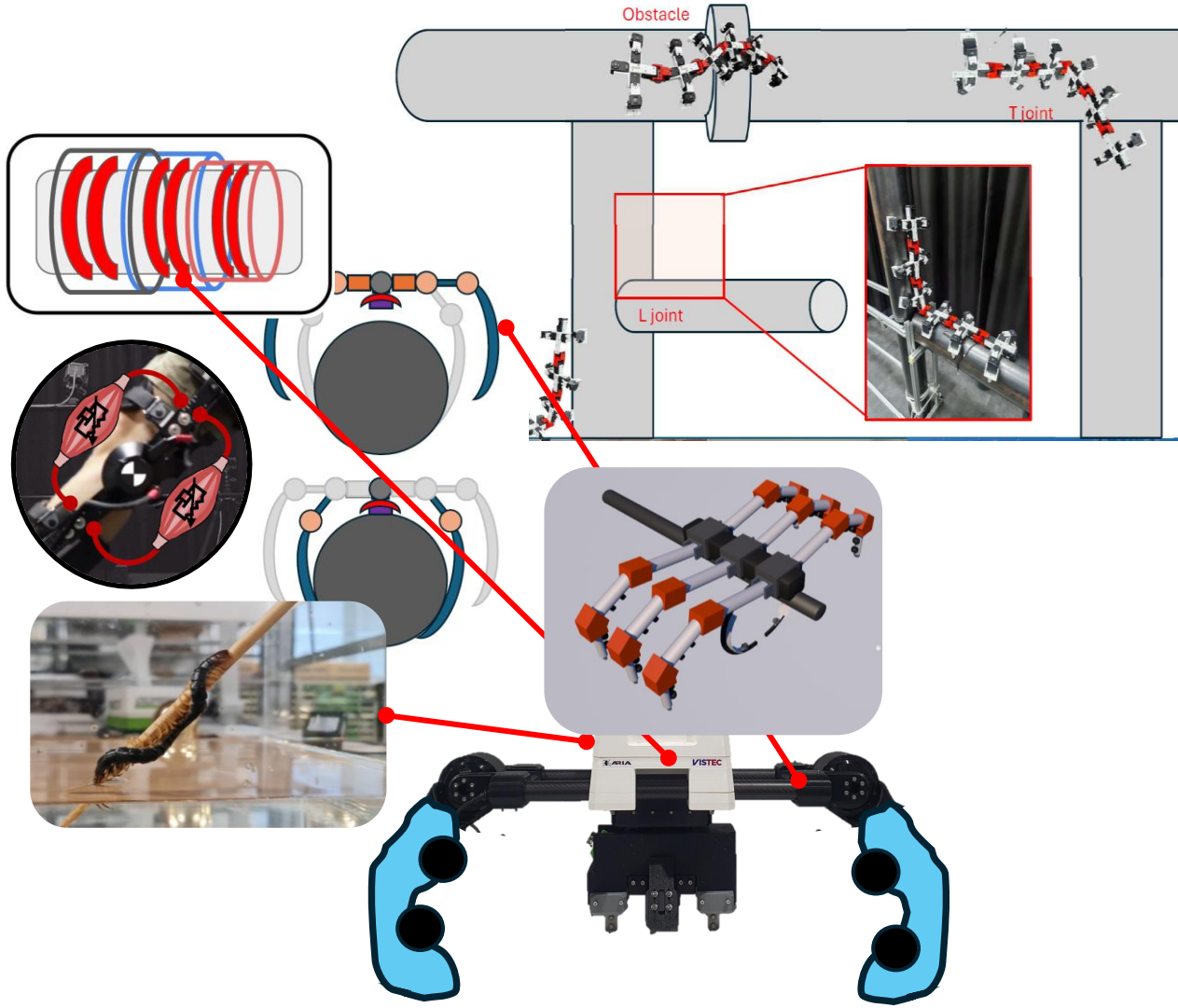

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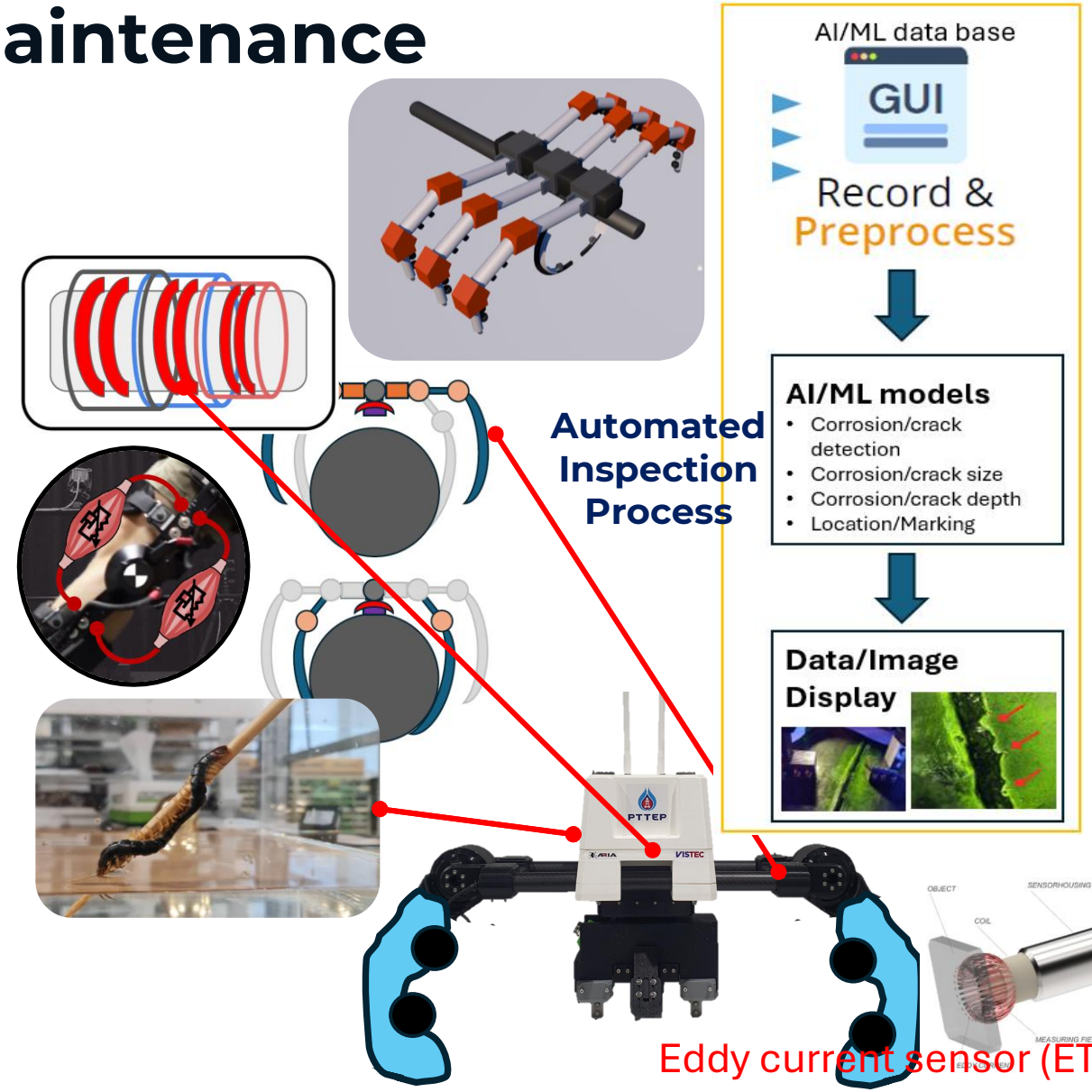
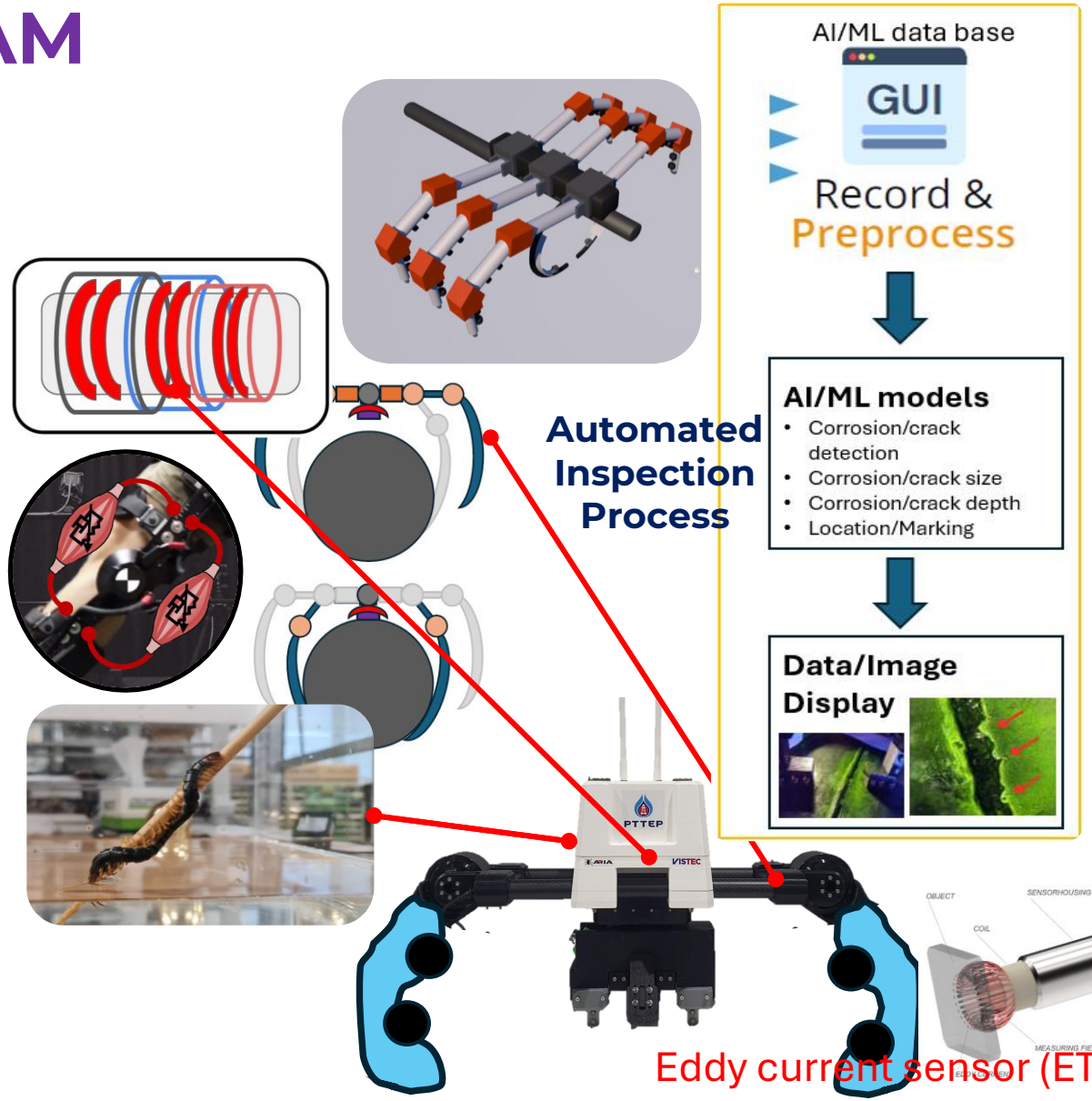


AI-NECS

RESEARCHER TEAM

VISTEC:
Dr. Poramate Manoonpong (Project Lead)
Mr. Kanut Tarapongnivat (Project Member, Tasks 1&4)
Mr. Run Janna (Project Member, Tasks 2&4)
Mr. Worameth Nantareekurn (Project Member, Tasks 3&4)

PTTEP:
Mr. Suppachai Pewkliang
Dr. Chatawut Chanvanichskul
Mr. Santi Thuengsripan



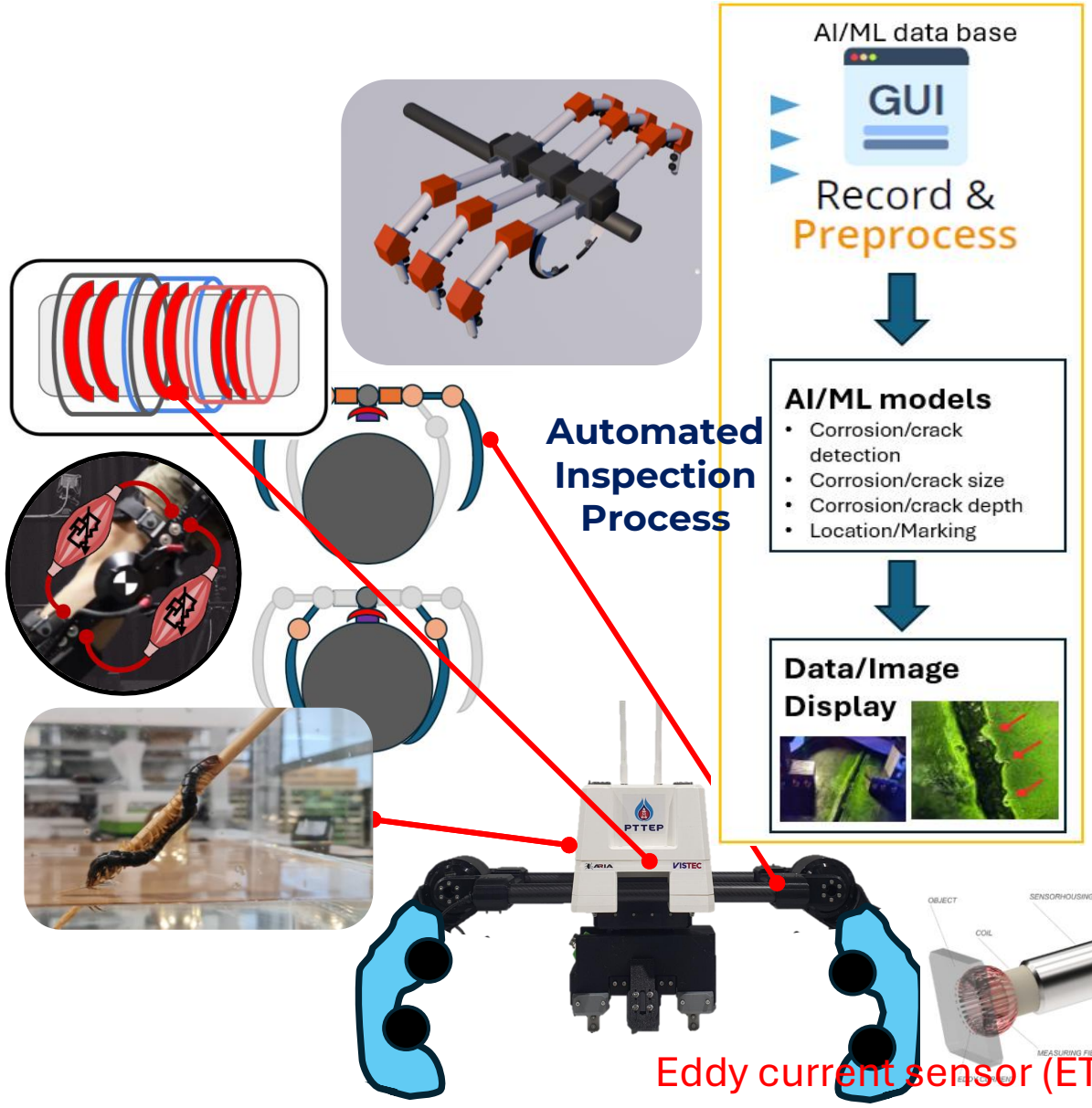
AI-NECS

PROJECT TIMELINE (2025-2028)

Task 1	2025-2027
Task 2	2025-2027
Task 3	2025-2027
Task 4	2027-2028

DELIVERABLES

- **Multipurpose inspection robot prototype** (software and hardware) for static equipment inspection onshore.
- **CENTIPOT robot prototype** (software and hardware) for complex (non ferromagnetic) structures
- **Publications & patents**



F-TECH (Freelander) → HERO (Freelander: HERO) → AI-NECS

OVERALL PROJECT PHASES

Address: Pillar 1 “Drive Value”

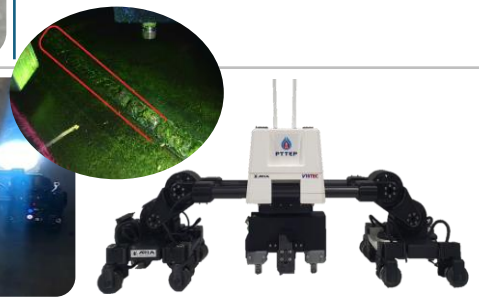
Research					Development		Deployment	
Phase 0 Idea	**Phase 1** Investigation		**Phase 2** Lab test		**Phase 3** Prototype test		**Phase 4** Pilot test	**Phase 5** Commercial
TRL 1	**TRL 2**	**TRL 3**	**TRL 4**	**TRL 5**	**TRL 6**	**TRL 7**	**TRL 8**	**TRL 9**
Basic Principle	Tech Concept	Proof of Concept	Lab Test	Bench Scale Test	Prototype in Relevant Environment	Integrated Prototype in Operational Environment	Act. Sys. completed & qualified through level and demonstration	Actual system proven through successful Operation

Phase 1

★ Adaptive Locomotion System Control System (F-TECH & VT)

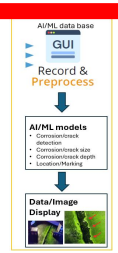
Phase 2

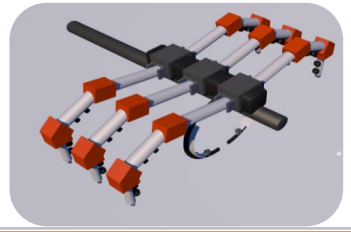
★ Advanced Hybrid LEgged-Wheeled RObot for Internal Vessel Inspection (HERO & MT)

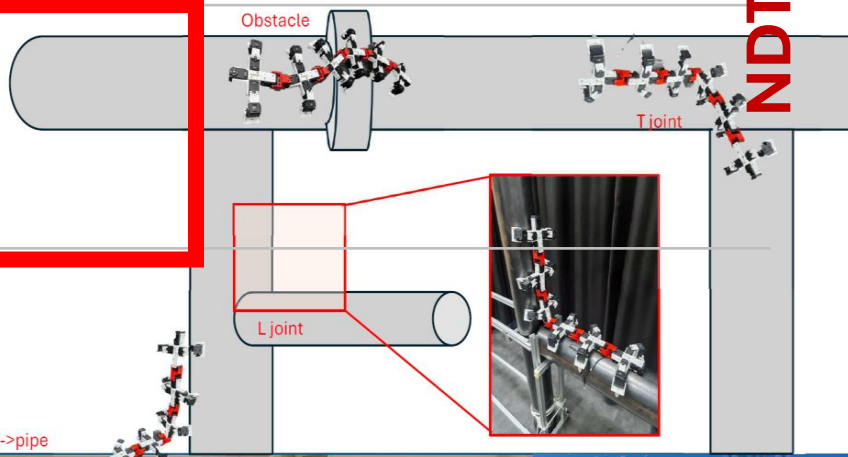


Phase 3

AI-Powered NExt-Generation RoboticS for InSpection and Maintenance (AI-NECS & CENTIPOT & UT/ET)







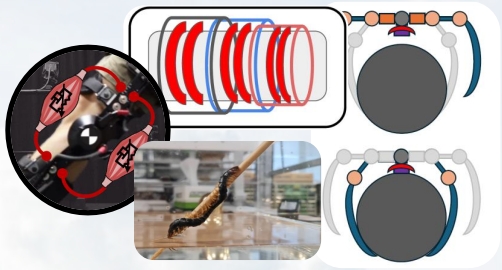
Overall Timeline: From Zero to HERO and AI-NECS

F-TECH/HERO

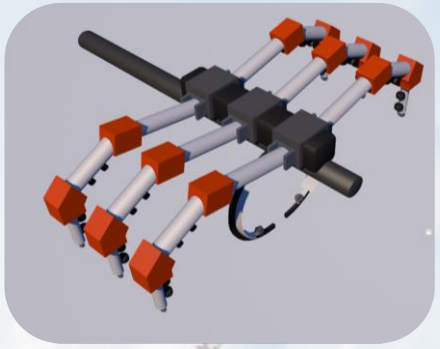
AI-NACS/MARINE

Adaptive locomotion control system development (F-TECH)
TRL 3-4

HERO prototype development
TRL 5



AI-NECS prototype development
TRL 3-5 (2025-2027)



CENTIPOT prototype development
TRL 5 (2027-2028)

NDT Inspection

VT **MT** **UT** **ET**

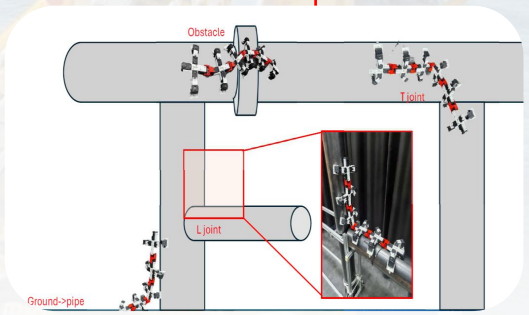
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

PTTEP

HERO prototype deployment
TRL 6 (Relevant Environment)

IRPC

HERO pilot deployment
TRL 7 (Operational Environment)



CENTIPOT prototype deployment
TRL 6 (Relevant Environment)

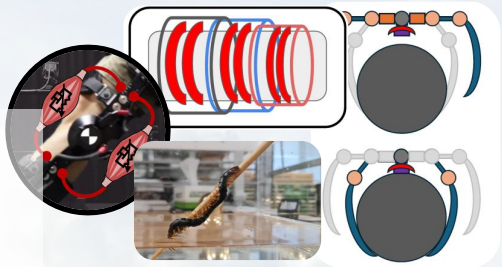
CENTIPOT pilot deployment
TRL 7 (Operational Environment)

Overall Timeline: From Zero to HERO and AI-NECS

F-TECH/HERO

AI-NACS/MARINE

HERO prototype development
TRL 5



AI-NECS prototype development
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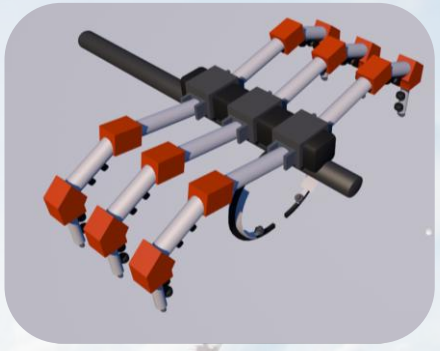


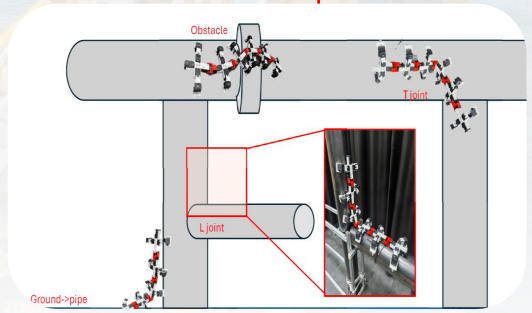
CENTIPOT prototype development
TRL 5 (2027-2028)

NDT Inspection

VT MT UT ET

2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

Inspection Robotics Technology Commercial roll out
TRL 8



CENTIPOT prototype deployment
TRL 6 (Relevant Environment)

CENTIPOT pilot deployment
TRL 7 (Operational Environment)

MARKET SIZE

PTTEP

PTTEP CONTACT POINT

MR. SUPPACHAI PEWKLIANG

Engineer, Technology Venture (OTM/A)

Email: suppachaip@pttep.com

Phone: +66(0)8 6392 3563

Discussion with

TAM
1.2 Billion +

SAM
576 M

SOM
300 M

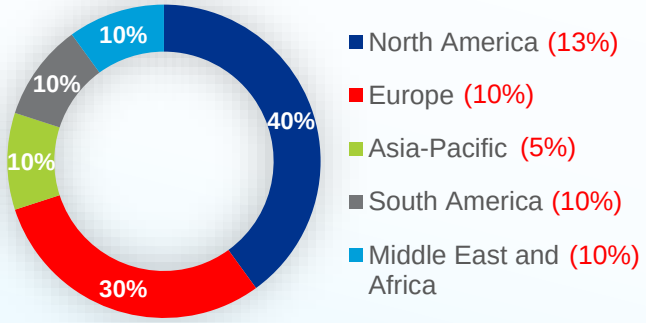
Inspection and Subsea Robot in Oil & Gas Industry → 30% of Global Inspection & Maintenance Robot Market

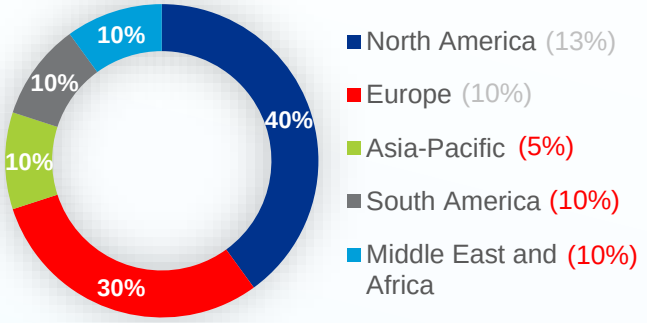
Freelander Robot Opportunity in 5 major regions → 48% of Inspection and Subsea Robot in Oil & Gas Industry

Freelander Robot Opportunity in target regions → 25% of Inspection and Subsea Robot in Oil & Gas Industry

Global Inspection & Maintenance Robot Market → 4 Billion + (Y2025)

CAGR 14.75% (2023 – 2030)





TAM: Total Addressable Market
SAM: Serviceable Addressable Market
SOM Serviceable Obtainable Market

Thank you for your attention

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