프로그램 주요일정

2026 1st
JPRI INTERNATIONAL Conference
(JBNU-Purdue Research Institute)

2026. 6. 12.(금) 10:00~18:00
전북대학교 인터내셔널센터 7층 동행홀

본 컨퍼런스는 전북대학교와 퍼듀대학교의 협력을 기반으로 글로벌 연구 네트워크 구축과 학술 교류 증진을 목적으로 합니다.

일정 Schedule	주요 내용 Program	발표자 Speakers
10:00 -10:30	등록 및 네트워킹 (Reg. & Networking)	
10:30 -11:00	개회식 (Opening Ceremony)	
11:00~11:20	JPRI 소개 및 비전발표 (JPRI Intro)	Kyung Soo Kook , Director, JPRI · Introduction to JBNU JPRI Martin Jun · Introduction to Purdue JPRI
11:20~11:40	기조강연1 (Keynote 1)	Dimitrios Peroulis, Senior Vice President, Purdue University · Purdue-JPRI Vision
11:40~12:00	기조강연2 (Keynote 2)	O-Bong Yang, President, Jeonbuk National University · JBNU On AI
13:30~15:10	Session 1	1 Safe and Secure Autonomy for Cyber-Physical Systems(CPS) : Applications to Aerospace Systems Inseok Hwang, Purdue University 2 Physical AI Leading Model Development and PoC (Proof of Concept) Sun Tae Kim , Jeonbuk National University 3 Challenges and Opportunities in Hybrid Additive Manufacturing for Functional Materials Michael Sealy, Purdue University 4 Thermal Engineering to Enable Next Generation Electronic Devices Amy Marconnet, Purdue University
15:10~15:30	휴식 (Coffee Break & Networking)	
15:30~17:10	Session 2	1 Spatial AI and Robotics: From 3D Perception to Autonomous Action HyungGi Jo, Jeonbuk National University 2 Smart Steering Wheel as the Next AI-Based Human-Machine Interface Jongsik Bae, Vice Presiden, DH Group 3 Nondestructive Evaluation for Advanced Manufacturing Luz Sotelo, Purdue University 4 AI-Driven Warfare and Rapid Acquisition: Implications for Korea-U.S. Defense Cooperation Won Joon Jang , Jeonbuk National University
17:10~17:30	종합정리 및 폐회 (Closing Remarks)	

JPRI JBNU-Purdue Research Institute · JEONBUK NATIONAL UNIVERSITY · PURDUE UNIVERSITY

"A Global Collaborative Research Platform for Advanced Technology Innovation"

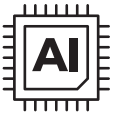
Institute Overview

Global Collaborative Research Hub
Promoting joint research between Jeonbuk National University and Purdue University

Educational Collaboration & Talent Development
Fostering globally competitive researchers through joint educational programs

Industry-Academia Collaboration
Promoting collaborative research and technology commercialization with industry partners

Research Areas



AI & Software



Mobility & Mechanical Systems



Advanced Materials & Energy



Smart Agriculture & Bio

Participation Scale

JBNU Researchers **25**

Purdue Researchers **27**

Industry Partners DH Group, Hyundai MOBIS, and Other Industry Partners

Global Research Network

Advancing Research Excellence and Technology Commercialization Through Industry-Academia Collaboration

“글로벌 공동연구 기반의 첨단기술 혁신 플랫폼”

연구소 개요

글로벌 공동연구 중심 운영
전북대-퍼듀대 공동연구를 통한 글로벌 연구 수행

교육 협력 및 인재 양성
공동 교육 프로그램 기반 글로벌 연구 인재 양성

산학협력 기반 연구 확장
기업 연계 연구 및 기술 사업화 추진

연구분야

AI/소프트웨어 | 기계·모빌리티 | 신소재/에너지 | 스마트팜/바이오

참여규모

전북대학교 연구진 25명

퍼듀대학교 연구진 27명

산학연 참여기관 DH그룹·현대로템 등 산업체 협력

글로벌 협력 한·미 공동연구 기반 글로벌 네트워크 운영

산학연 연계를 통한 연구성과 창출 및 기술사업화 추진

INVITATION

Dear Distinguished Guests, Scholars, Researchers, and Participants,
It is my great pleasure to extend my warmest welcome to all of you attending the 2026 JPRI International Conference.

Today, our world is undergoing a period of unprecedented transformation driven by the global energy transition and the rapid advancement of artificial intelligence (AI). In response to these challenges and opportunities, the JBNU - Purdue Research Institute (JPRI) was established as a global collaborative research platform jointly founded by Jeonbuk National University and Purdue University.

Through the partnership between Jeonbuk National University, a flagship university of the Republic of Korea striving to become a Global Top 100 institution, and Purdue University, a world-renowned university distinguished by its persistent pursuit of innovation, JPRI seeks to create transformative synergies that will help shape the future of humanity.

More than a platform for academic exchange, JPRI aims to establish a sustainable framework for genuine research collaboration, where scholars from both institutions jointly design and conduct research projects and produce world-class outcomes. Furthermore, JPRI aspires to serve as a hub for Industry - Academia - Research partnerships between Korea and the United States, fostering new opportunities for research, education, and innovation while creating future growth engines for both nations.

This conference marks the very first event since the establishment of JPRI and is being held at the Jeonbuk National University Jeonju Campus in a hybrid format, enabling both in-person and virtual participation. In the morning session, we are honored to host keynote speeches by President Yang O-bong of Jeonbuk National University and Executive Vice President Dimitrios Peroulis of Purdue University. In the afternoon, researchers from JPRI at both Purdue University and Jeonbuk National University will present their latest research achievements in key areas such as artificial intelligence, robotics, and energy systems. In addition, representatives from DH Group will share recent developments in autonomous driving technologies, followed by an interactive discussion session.

As Purdue alumnus Neil Armstrong famously declared when he first stepped onto the surface of the Moon, “That's one small step for man, one giant leap for mankind.” In the same spirit, I sincerely hope that the 2026 JPRI International Conference, the first step in JPRI’s journey, will become a catalyst for a giant leap forward toward a truly global collaborative research platform.

Once again, I would like to express my heartfelt gratitude to all participants, speakers, and guests for joining us. I wish you a productive, inspiring, and memorable conference experience.

Thank you.

Sincerely,

June 12, 2026
Prof. Kyungsoo Kook Director of JPRI Jeonbuk National University, Korea

안녕하십니까?

「2026년 JPRI International Conference」에 참석해 주신
모든 분들께 진심으로 감사와 환영의 말씀을 드립니다.

오늘날 세계는 에너지전환과 인공지능(AI)시대를 맞이하면서
과거의 어떤 산업혁명보다도 크고 급격한 변화의 시기를 맞이하고 있습니다.
JPRI(JBNU-Purdue Research Institute)는 이러한 시대적 상황 속에서
대학의 역할을 적극적으로 수행하기 위해 전북대학교와 퍼듀대학교가 함께 설립한
글로벌 공동연구 플랫폼입니다.

대한민국의 플래그십 대학으로써 글로벌 Top100을 지향하는 전북대학교와,
지속적인 혁신의 DNA를 품고 있는 세계적 명문대학인 퍼듀대학교 간의 협력을 통해
인류의 미래를 준비하기 위한 혁신적인 시너지를 창출하고자 합니다.

특히 JPRI는 단순한 학술교류를 넘어 양 교의 연구자들이 함께 연구를 기획하고 수행하며,
세계적 수준의 연구성과를 창출하는 실질적인 협력체계 구축을 목표로 하고 있습니다.
또한 한미 간 산학연 협력의 구심점 역할을 통해 새로운 연구와 교육의 기회를 발굴하고
미래 성장동력을 창출하는 역할을 적극 수행하고자 합니다.

이번 컨퍼런스는 JPRI 설립 후 치르는 첫 번째 행사로써
전북대학교 전주캠퍼스에서 개최되며 대면/비대면 하이브리드 방식으로 진행됩니다,
오전에는 전북대학교 양오봉 총장님과 퍼듀대학 Dimitrios Peroulis 부총장님의 기조 강연이 준비되어 있고,
오후에는 퍼듀대학교 JPRI 연구진과 전북대학교 JPRI 연구진이 AI, 로보틱스, 에너지 등 핵심 분야의
최신 연구 현황을 발표하고 특히 DH그룹에서는 자율주행 분야의 핵심기술에 대한 기술개발 현황을 발표하여
토론을 진행합니다.

퍼듀대 동문인 닐 암스트롱(Neil Armstrong)이 달 표면에 첫발을 내디디며 남긴 문구처럼
JPRI의 첫 걸음인 2026년 국제 학술대회가
글로벌 공동연구 플랫폼으로의 위대한 도약의 계기가 되기를 진심으로 기원합니다.
다시 한번 2026년 JPRI 국재 컨퍼런스에 함께해주신 모든 분들께 감사드리며,
뜻깊고 유익한 시간이 되시기를 기원합니다.

감사합니다.



2026년 6월 12일
전북대학교 - 퍼듀대학교 고등연구소(JPRI)
연구소장 국경수

WELCOME MESSAGE

Distinguished guests, ladies and gentlemen,

It is a great pleasure to welcome you all to this meaningful gathering jointly hosted by Jeonbuk National University and Purdue University during this beautiful early summer season, when the campus is filled with vibrant greenery. I sincerely appreciate your presence despite your busy schedules.

In particular, I would like to express my deepest gratitude to Senior Vice President Dimitrios Peroulis of Purdue University and the distinguished Purdue faculty members who have traveled a long distance to visit Jeonbuk National University.

I would also like to warmly welcome representatives from Jeonbuk State, industry and research institutions, as well as researchers and students from Korea and abroad.

Today, we gather to share the future direction and research achievements of JPRI (Jeonbuk National University - Purdue Research Institute), a global collaborative research platform jointly developed by Jeonbuk National University and Purdue University.

If the JPRI inauguration ceremony held this past March marked a new beginning in the partnership between our two institutions, today's conference demonstrates how that partnership is expanding into practical research collaboration, technological exchange, and concrete joint research initiatives.

Purdue University is a globally renowned institution with world-leading competitiveness in fields such as aerospace, defense, industrial engineering, and computer science and artificial intelligence, supported by its outstanding research capabilities and innovative educational system.

Jeonbuk National University is likewise striving to become a globally oriented research university that connects the region to the world through strategic fields including future mobility, advanced defense, physical AI, energy systems, and food technology.

In particular, through JPRI, we aim to strengthen cooperation with world-class research institutions and industries, secure future growth engines for the region, and establish a globally competitive system for research and talent development.

I firmly believe that today's gathering will serve as a new starting point where the research capabilities of our two universities come together and where academia, technology, and people become more deeply connected. Furthermore, I hope this partnership will continue to grow into a global platform for collaborative research where universities, industries, regions, and the international community advance together.

Once again, I sincerely thank all of you for joining us today. As you visit our campus during this wonderful season, I hope you will also have the opportunity to experience the unique charm, warmth, and cultural spirit of Jeonbuk.

Thank you very much.

June 12, 2026

O-Bong Yang President of Jeonbuk National University

안녕하십니까. 전북대학교 총장 양오봉입니다.

초여름의 푸르름이 짙어가는 이 좋은 계절에,
전북대학교와 퍼듀대학교(Purdue University)가 함께하는
뜻깊은 자리를 마련하게 되어 매우 기쁘게 생각합니다.
바쁘신 일정 속에서도 귀한 걸음을 해주신 여러분을 진심으로 환영합니다.

특히 먼 길을 마다하지 않고 전북대학교를 찾아주신
퍼듀대학교(Purdue University) 디미트리오스 페롤리스(Dimitrios Peroulis) 부총장님을 비롯한
퍼듀대학교 교수님들께 깊이 감사드립니다.

아울러 전북특별자치도와 산업계, 연구기관 관계자 여러분,
그리고 국내외 연구자와 학생 여러분께도 따뜻한 환영의 인사를 드립니다.

오늘 우리는 전북대학교와 퍼듀대학교가 함께 구축해가고 있는 글로벌 공동연구 플랫폼
JPRI(Jeonbuk National University - Purdue Research Institute)를 중심으로,
미래 협력의 방향과 연구성과를 공유하는 뜻깊은 자리에 함께하고 있습니다.

지난 3월 JPRI 개소식을 통해 양 기관 협력의 새로운 출발을 알렸다면,
오늘 컨퍼런스는 그 협력이 실제 연구와 기술 교류, 그리고 구체적인 공동연구로 확장되고 있음을
보여주는 매우 의미 있는 자리라고 생각합니다.

퍼듀대학교는 세계적 연구역량과 혁신적 교육 시스템을 바탕으로 항공우주(Aerospace), 방산(Defense),
산업공학(Industrial Engineering), 컴퓨터 및 인공지능(Computer Science and Artificial Intelligence) 분야에서
글로벌 최고 수준의 경쟁력을 보유한 명문대학입니다.

전북대학교 또한 미래모빌리티(Future Mobility), 첨단방산(Advanced Defense),
피지컬 AI(Physical AI), 에너지 시스템(Energy Systems), 푸드테크(Food Tech) 등
전략 분야를 중심으로 지역과 세계를 연결하는 글로벌 연구중심대학으로 도약하기 위해 힘쓰고 있습니다.

특히 JPRI를 중심으로 세계 수준의 연구기관 및 산업체와의 협력을 강화하여
지역의 미래 성장동력을 확보하고 글로벌 경쟁력을 갖춘 연구 및 인재양성 체계를 구축해 나가고자 합니다.

저는 오늘 이 자리가 양 대학이 가진 연구 역량을 하나로 모으고,
학문과 기술, 그리고 사람과 사람이 연결되는 새로운 출발점이 될 것으로 확신합니다.
나아가 대학과 산업 지역과 세계가 함께 성장하는 글로벌 연구 협력의 플랫폼으로 발전해 나가기를 기대합니다.

다시 한 번 참석해 주신 모든 분들께 깊이 감사드리며,
좋은 계절에 전북대학교 캠퍼스를 찾으신 만큼
한국적 정취가 살아 숨 쉬는 이곳에서 잠시 여유를 느끼시고,
전북이 지닌 따뜻한 정서와 낭만도 함께 만끽하셨으면 좋겠습니다.

감사합니다.



2026년 6월 12일

전북대학교 총장 양오봉

2026 1st JPRI INTERNATIONAL Conference

(JBNU–Purdue Research Institute)



JPRI
JBNU–Purdue Research Institute

JEONBUK
NATIONAL UNIVERSITY

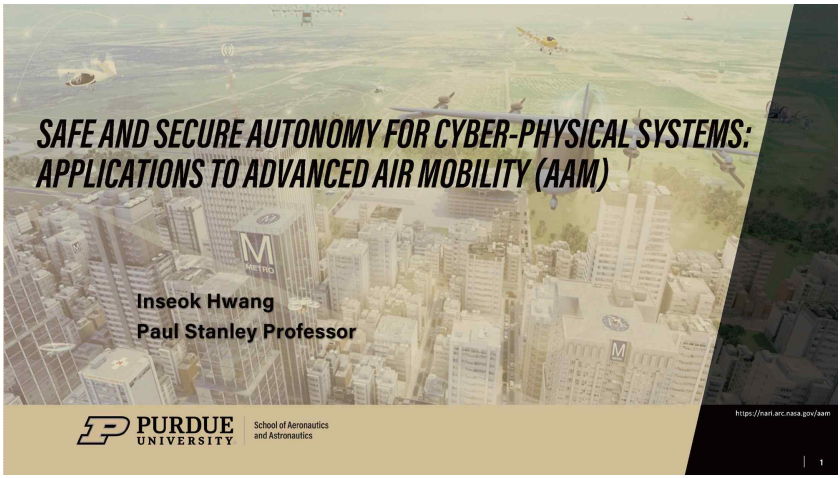
PURDUE
UNIVERSITY

SESSION I

1. **Safe and Secure Autonomy for Cyber-Physical Systems(CPS) : Applications to Aerospace Systems**
   Inseok Hwang, Purdue University
2. **Physical AI Leading Model Development and PoC (Proof of Concept)**
   Sun Tae Kim, Jeonbuk National University
3. **Challenges and Opportunities in Hybrid Additive Manufacturing for Functional Materials**
   Michael Sealy, Purdue University
4. **Thermal Engineering to Enable Next Generation Electronic Devices**
   Amy Marconnet, Purdue University

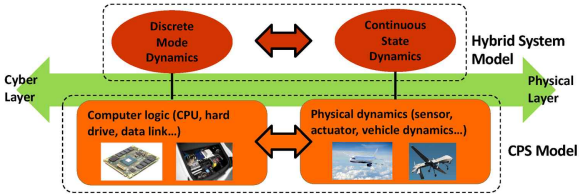
JEONBUK NATIONAL UNIVERSITY

PURDUE UNIVERSITY



Cyber-Physical System (CPS) Model: Hybrid System

- The CPS consists of **interacting logical elements** such as embedded computers and **physical elements** connected by communication channels → **Hybrid Systems Framework**



- **Hybrid Systems Approach** to modeling, information inference, and control of **Cyber-Physical Systems (CPS)** with **applications to Aerospace Systems**

- **CPS Applications of Hybrid Systems**
  - **Intelligent systems:** aircraft/spacecraft/UAS/UAM/Automobile …
  - **Networked systems**: transportation systems, sensor networks, and multiple-vehicle systems

High Assurance Control

- **Assured CPS autonomy applications**
  - A wide range of **safety critical CPSs,** from **autonomous systems** (e.g., UAS/AAM) to **human-machine interaction** (HMI) systems, and to **networked systems** (e.g., ATC, UTM, Smart Power Grid)


Complex dynamics

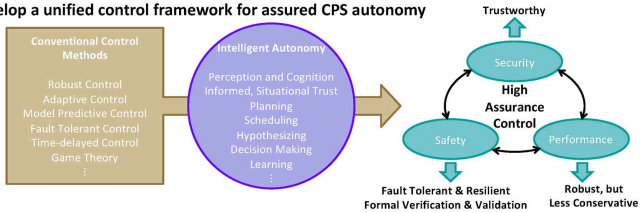

User Interaction


Large-scale Network


Harsh Environment ...

  - Each requires **elaborate control tasks** under **different operating conditions**
    → ***Conventional control methods could not be directly applicable to assure the CPS***

- **Develop a unified control framework for assured CPS autonomy**



Urban Air Mobility (UAM) Outlook

Urban Air Mobility (UAM) systems are emerging for short-range transportation in the metropolitan areas

- ***High number/greater density*** *of operations*
- *Varying performance of* ***different operators and air vehicles***

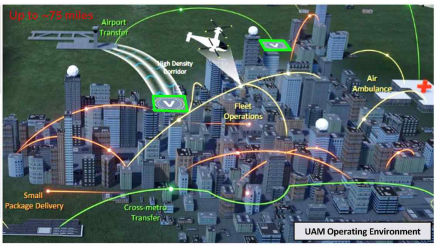
- **UAM** is the use of small, highly automated aircraft to ***carry passengers or cargo*** at lower altitudes in ***urban areas***
  - ***"Local"*** missions up to ***75 miles*** around ***metropolitan areas***
  - **electric Vertical Take-Off and Landing** (***eVTOL***) aircraft can load up to ***6 passengers*** or equivalent ***cargo***
  - Largely novel ***"vertiport"*** infrastructure



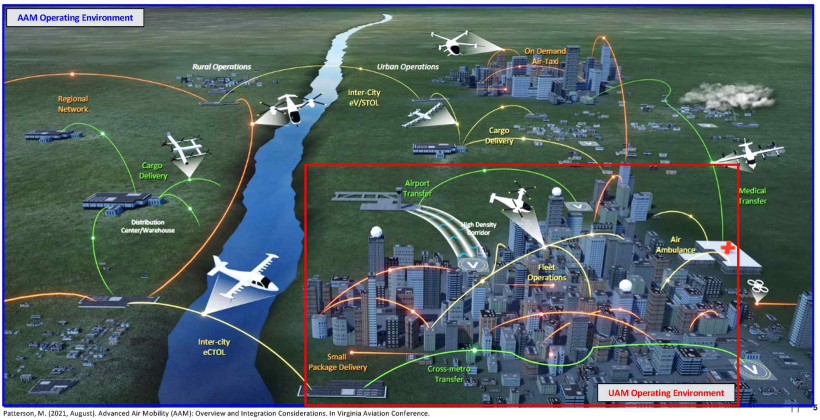
https://www.airbus.com/en/innovation/zero-emission/urban-air-mobility



https://about.ups.com/ae/en/newsroom/press-releases/innovation-driven/ups-flight-forward-adds-new-aircraft.html



Extension to Advanced Air Mobility (AAM)



Patterson, M. (2021, August). Advanced Air Mobility (AAM): Overview and Integration Considerations. In Virginia Aviation Conference.

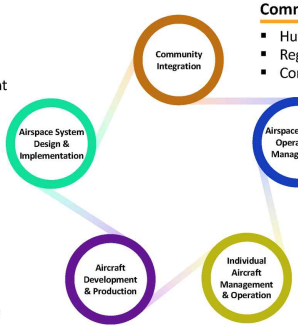
NASA AAM Mission Priorities

Airspace System Design & Implementation

- eXtensible Traffic Management (xTM) Architectures
- Operational Rules, Roles, & Procedures
- Command, Navigation, Surveillance, and Information

Aircraft Development & Production

- Source and Fleet Noise
- Vehicle Propulsion Reliability
- Environmental and Failure Conditions
- Distributed Electric Propulsion



Community Integration

- Human Response to Noise
- Regional M&S Capabilities, & Supply Chain
- Community Integration

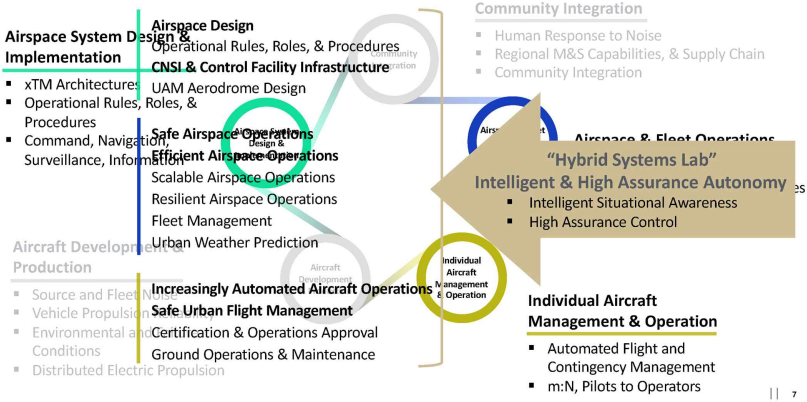
Airspace & Fleet Operations Management

- UAM Supplemental Data Services
- In-time Aviation Safety Management System

Individual Aircraft Management & Operation

- Automated Flight and Contingency Management
- m:N, Pilots to Operators

NASA AAM Mission Priorities – Identified Barriers



Hybrid Systems Lab Research Overview



Airspace Design
- Dynamic Airspace Configuration

Communications, Navigation, Surveillance, and Information (CNSI)
- Surveillance for UAS with Geofencing

Safe Airspace Operations
- Conformance Monitoring and Online Anomaly Monitoring
- Adverse Event Prediction and Precursor Discovery
- Data-driven Conflict Resolution

Efficient Airspace Operations
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- Trajectory Prediction for Trajectory-Based Operations (TBO)

Increasingly Automated Aircraft Operations (Human-Machine Interactions)
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- Skill-level-based Hybrid Shared Control for Human-Automation Systems

Safe Urban Flight Management (Cyber Security)
- Cyber Security Analysis of UAS (Strategy & Secure Design)
- Distributed Resilient Control under Cyberattacks

Conformance Monitoring for Aircraft Taxiway

For safe airspace operations, safety monitoring is critical to identify deviations that might compromise safety and efficiency and thus contributes to rectifying the problems in real-time

- **A380 hits a CRJ at JFK airport** http://www.nbcnewyork.com/news/local/Two-Planes-Collide-on-Ground-at-JFK-119666334.html
- **Near miss at JKF between A340 and B777**: Lufthansa 411 must slam on breaks to avoid Egypt Air 986 which failed to follow the assigned taxi-route http://www.nbcnewyork.com/news/local/Jumbo-Jets-In-Near-Miss-at-JFK--124341539.html



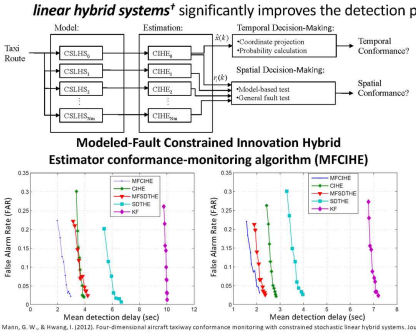
Taxiway and runway incursions

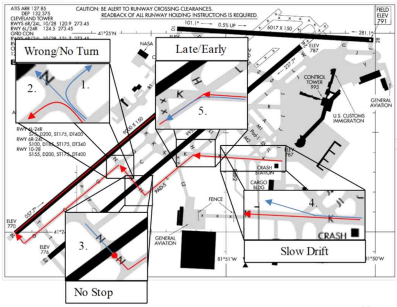
- **Safety Monitoring: Conformance Monitoring**
  - Detection of deviations which might compromise safety and efficiency
  - Conformance monitoring in air traffic control and taxiway

Conformance Monitoring for Aircraft Taxiway

For safe airspace operations, safety monitoring is critical to identify deviations that might compromise safety and efficiency and thus contributes to rectifying the problems in real-time

- ***Taxiway conformance monitoring algorithm**** based on ***fault detection and identification for constrained stochastic linear hybrid systems**†*** significantly improves the detection performance



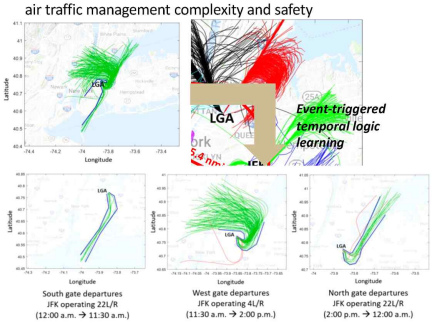


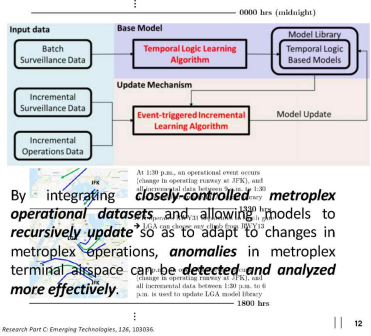
* Mann, G. W., & Hwang, I. (2012). Four-dimensional aircraft taxiway conformance monitoring with constrained stochastic linear hybrid systems. Journal of guidance, control, and dynamics, 35(5), 1593-1604.
† Mann, G., & Hwang, I. (2013). State estimation and fault detection and identification for constrained stochastic linear hybrid systems. IET Control Theory & Applications, 7(1), 1-15.

Online Anomaly Monitoring in Terminal Airspace

For safe airspace operations, safety monitoring is critical to identify deviations that might compromise safety and efficiency and thus contributes to rectifying the problems in real-time

- Big Data-based ***analysis of anomalous behaviors in complex operations**** become more important in understanding air traffic management complexity and safety





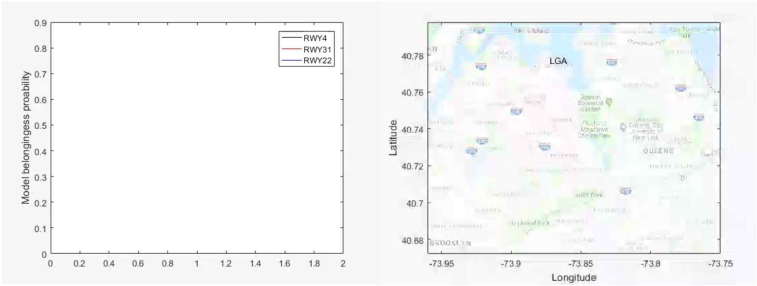
By integrating ***closely-controlled**** ***metroplex operational datasets***, and allowing models to ***recursively update**** so as to adapt to changes in metroplex operations, ***anomalies*** in metroplex terminal airspace can be ***detected and analyzed more effectively***.

* Deshmukh, R., Sun, D., Kim, K., & Hwang, I. (2021). Temporal logic learning-based anomaly detection in metroplex terminal airspace operations. *Transportation Research Part C: Emerging Technologies, 126*, 103036.

Online Anomaly Monitoring in Terminal Airspace

For safe airspace operations, safety monitoring is critical to identify deviations that might compromise safety and efficiency and thus contributes to rectifying the problems in real-time

- By applying model inference to real-time streaming data, ***online anomaly monitoring**** can be achieved based on the ***temporal logic models*** in complex terminal airspace



Illustrative example of online anomaly monitoring for arrival to LGA Rwy 31

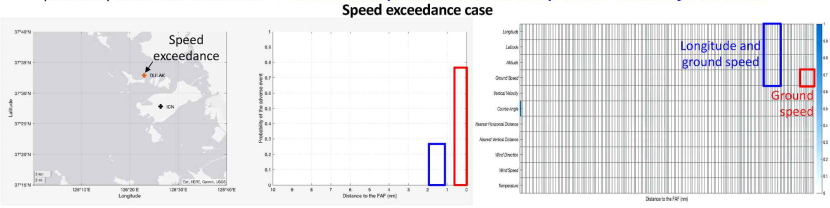
* Deshmukh, R., Sun, D., Kim, K., & Hwang, I. (2021). Temporal logic learning-based anomaly detection in metroplex terminal airspace operations. *Transportation Research Part C: Emerging Technologies, 126*, 103036.

Adverse Event Prediction and Precursor Discovery

For safe airspace operations, safety-related issues and their causes can be found in advance by predicting adverse events in advance, thereby rectifying the problems in real-time

- ***Temporal precursor discovery*** can provide adverse event probability and identify which features cause the probability to increase in real-time → ***More accurate prediction and real-time precursor detection for resolution***

Speed exceedance case

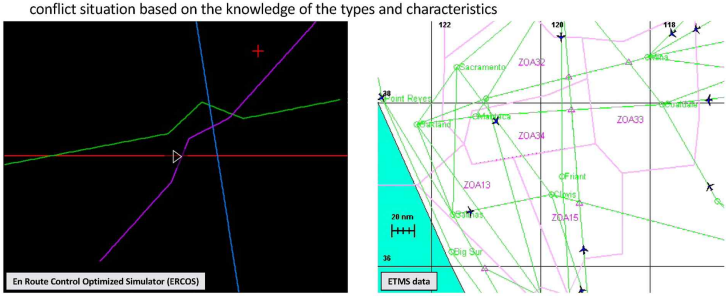


* Dang, C., Choi, H. C., Park, H., & Hwang, I. (2023.) Temporal Precursor Discovery Using LSTM with Feature Attention. *Journal of Aerospace Information Systems*.

Data-Driven Conflict Resolution

For safe airspace operations, conflict resolution can contribute to an automated system as well as guaranteed safety under uncertainties from various sources

- A ***Data-Driven Resolution Generator (D2RG)**** can automatically synthesize a resolution strategy for a given conflict situation based on the knowledge of the types and characteristics



Effective resolution strategies can be generated automatically to guarantee safety

* Kim, K., Deshmukh, R., & Hwang, I. (2021). Development of data-driven conflict resolution generator for en-route airspace. *Aerospace Science and Technology, 114*, 106744.

Hybrid Systems Lab Research Overview

Airspace System Design & Implementation

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- Dynamic Airspace Configuration

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Airspace & Fleet Operations Management

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Background

- What is the **Human-Machine Interaction (HMI)** ?
  - **Human-Machine Interaction (HMI)** is a key element for the successful applications of **Cyber-Physical Human Systems (CPHS).**
  - HMI enables humans to safely and effectively control complex CPHS by interacting with machine/automation, such as aircraft, automobiles, traffic systems, nuclear power plants, manufacturing plants, military and medical systems.







https://innovator.news/chinas-drive-to-dominate-autonomous-cars-848941b95961f

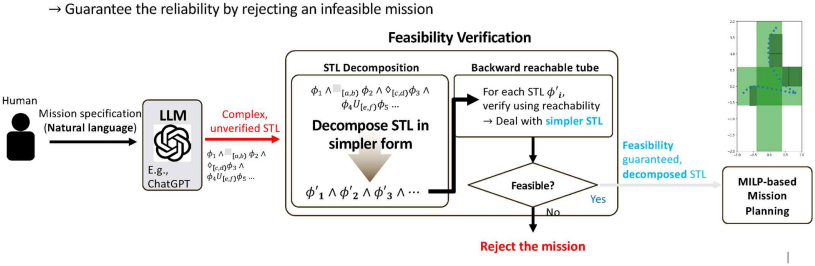


http://innopedia.wikidot.com/nextgen-defined

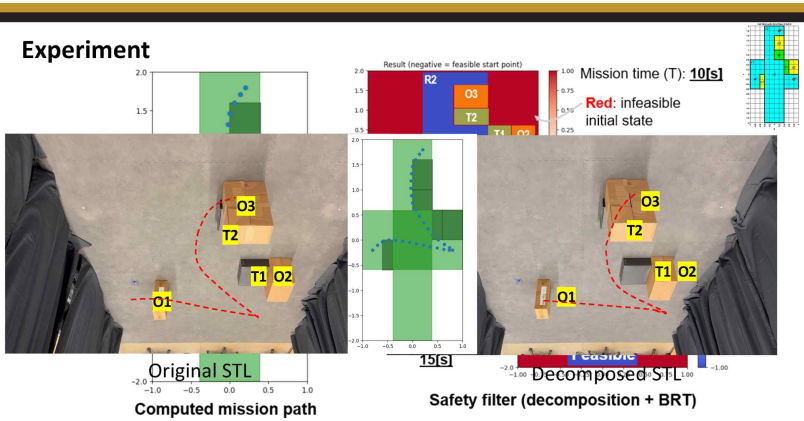
Large Language Model (LLM)-based Human-Autonomy Teaming

Develop a framework for reliable HAT, that **formally verifies** the behavior of LLM in a **pre-validation** manner

- LLM is leveraged as a translator that transfer **humans' natural language commands to Signal Temporal Logic (STL) specification**
- **Decompose** the the generated STL into simpler STLs
- **Verify the feasibility** of the STL using backward reachable tube
  → Guarantee the reliability by rejecting an infeasible mission



Experiment



Current Direction: Cognitive Autonomy

Cognitive Cooperative Control for Reliable AAM

"Optimal human-Machine Cooperation [1]" for reliable AAM in high uncertainty

Human Cognitive Model

- Estimate cognitive state (e.g., workload, trust, and self-confidence)
- Measure physio-psychological data (e.g., EEG and eye-tracker)



Electroencephalography (EEG)

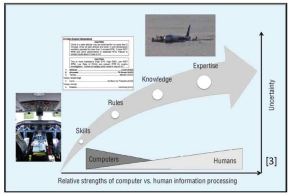




[2]

Dynamic Roll Allocation

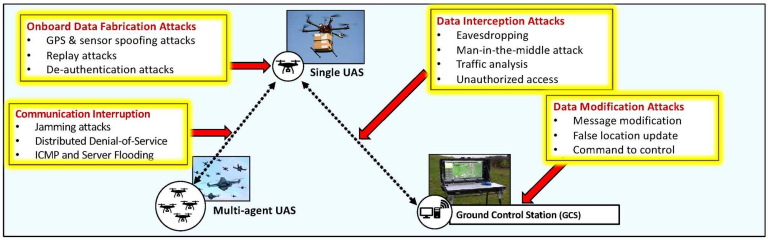
- Skill-Role-Knowledge based dynamic role allocation between human and autonomy
- Symbiosis of human-machine systems by exploiting human cognitive capabilities in uncertain environment



[1] Hoc et. al., "Cooperation between drivers and automation: implications for safety," Theoretical Issues in Ergonomics Science 2009
[2] W. Hu et. al., "The Relationship Between Design Outcomes and Mental States During Ideation," Journal of Mechanical Design 2017
[3] Cummings, "Man versus Machine or Man + Machine?" IEEE Intelligent Systems 2014

Cybersecurity Analysis of UAS/UAM

Big Picture of Cyberattack Vulnerabilities in Single & Multi UAS/UAM Components:



Cyberattacks in the vulnerable **control and communication link** between GCS and UAS
- Penetrating the information security, **Man-in-the-Middle attacks** could be the one of the *worst-case attack*

Cyberattacks compromising the **onboard sensors**
- No foolproof way to detect and identify such attacks!
- **GPS and sensor spoofing attacks** have been demonstrated to be *easy to implement* on real UAS applications

Cyberattacks **disrupting the communication network** of Multi-agent UAS
- Information disconnections/disruptions block a collaborative behavior between UASs!
- **Distributed Denial-of-Service attacks** have been reported in many Multi-agent UAS applications

Cybersecurity Analysis for Cyber-Physical Systems

- What if the cyber attacker break the information security protection?



Potential Cyber Threat

Controls Domain Approach
:Focus on the **dynamics of CPS tampered by cyber attacks**

Information Security (Computer Science Perspective)
- Focus on **data validation** (Integrity, Authentication, Availability, etc.)
- Key component of **hardware/software layer** in computer-controlled system
- **Do not address the dynamical behavior of the CPS under cyber attacks!**

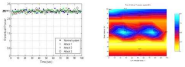
- Characterize and assess the **compromised behavior of the CPS** with **different analysis tools**

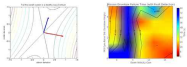
Dynamical Models of CPS and Cyber Attacks

- **Theoretical Analysis:**
  - Cyber attack detectability; and
  - Cyber attack severity analysis
- **Numerical Simulation & Experiment**



Analysis of CPS subject to cyber attacks



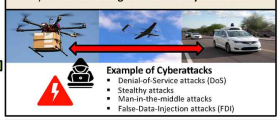


Result analysis for algorithm development

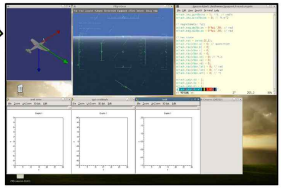
Cybersecurity Analysis

Objective: Characterize and Analyze the Compromised Behavior of the CPS with Different Analysis Tools

Dynamic **Modeling** of **CPSs** and **Cyberattacks**

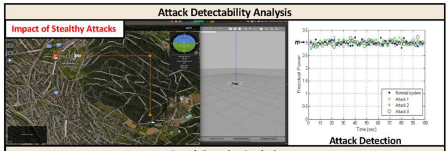


Example of Cyberattacks
- Denial-of-Service attacks (DoS)
- Stealthy attacks
- Man-in-the-middle attacks
- False-Data-Injection attacks (FDI)

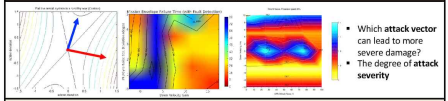


- Cyberattack **detectability** & **attack severity** analysis
- Potential **risk assessment** of cyberattacks
- Numerical simulations & experiments

Attack Detectability Analysis

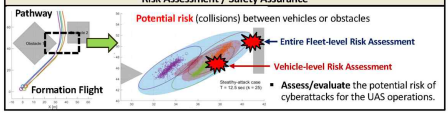


Attack Severity Analysis



- Which **attack vector** can lead to more severe damage?
- The degree of **attack severity**

Risk Assessment / Safety Assurance



Potential **risk** (collisions) between vehicles or obstacles

- **Entire Fleet-level Risk Assessment**
- **Vehicle-level Risk Assessment**
- **Assess/evaluate** the potential risk of cyberattacks for the UAS operations.

Purdue UAS Research and Test (PURT) Facility

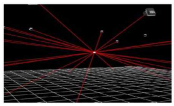
Purdue Airport Hangar 4:

- **Real Experiment Capabilities:**

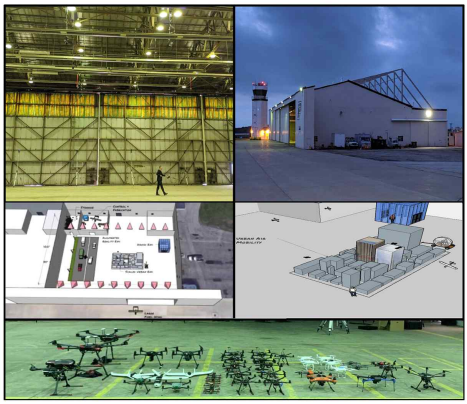
- ***World's largest indoor motion capture facility***, Size: 20,000 sqft with 30 ft ceiling
- Motion capture tracks rigid bodies with active or passive markers and enables:
  - ***Mixed-reality*** environments
  - ***Sensor-emulation***: GPS, ultra-sonic, ADS-B, LIDAR, ToF, etc
  - ***Ground truth***: Provides mm position and 0.1 deg attitude
- Motion Capture Camera: **Qualisys Oqus 7+**
  - ***Industry leading*** motion capture camera
  - **Versatile** and **Fast,** Mode 1: 300 fps, 12 MP, Mode 2: 1100 fps, 3 MP, **active** or **passive**
  - **Weather-proofing**: IP67 rating, important in the hangar and for outdoor use



Qualisys Oqus 7+

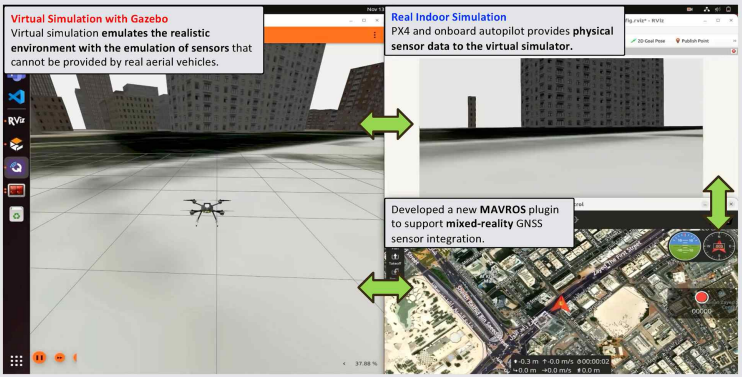


Motion Capture Platform



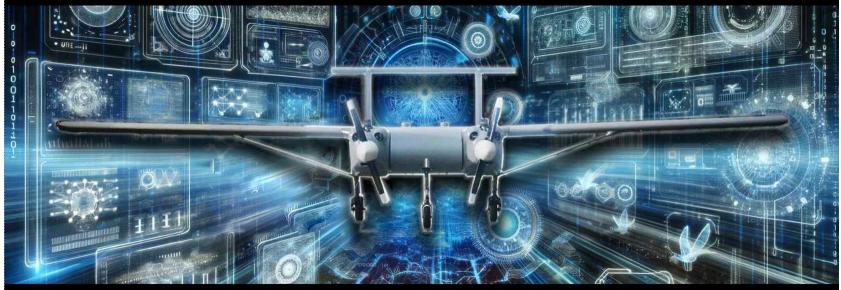
Validation & Verification

Mixed-Reality Testbeds Demonstration:



AIDA³

Artificial Intelligence for Digital, Autonomous, and Augmented Aviation



AIDA³ : Artificial Intelligence for Digital, Autonomous, and Augmented Aviation

OUR MISSION: We pioneer applied and experimental research in safe AI/ML systems to transform aerial autonomy with real-world impact

Purdue's World-Class Test Beds

PURDUE UNIVERSITY OWNED AIRPORT



Teaching Research Airport (KLAF)

WINDRACERS ULTRA



Largest dual-use drone in US

PURT – PURDUE UAV RESEARCH & TEST FACILITY



World's largest indoor motion-capture, mm-precision

PAAL – PURDUE AUGMENTED AVIATION LAB



advanced VR/AR, motion capture, biometric wearables

PUC* – PURDUE URBAN CANYON LAB

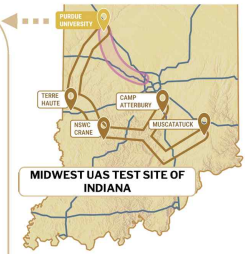


12-acre urban canyon, cm-accuracy for digital twins

EARHART AIRFIELD*



Dedicated UAS Airfield.



* Construction plan in process.

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- **Graduate Students:** Kartik Pant, Sounghwan Hwang, and Vishnu Vijay

- **Sponsors**

THANK YOU

PURDUE UNIVERSITY | School of Aeronautics and Astronautics

Ministry of Science and ICT

nipa 정보통신산업진흥원 National IT Industry Promotion Agency

2025 Industry-Specialized Physical AI Leading Model Development & PoC (Proof of Concept)

Outcomes and JBNU's Manufacturing Physical AI Lab.

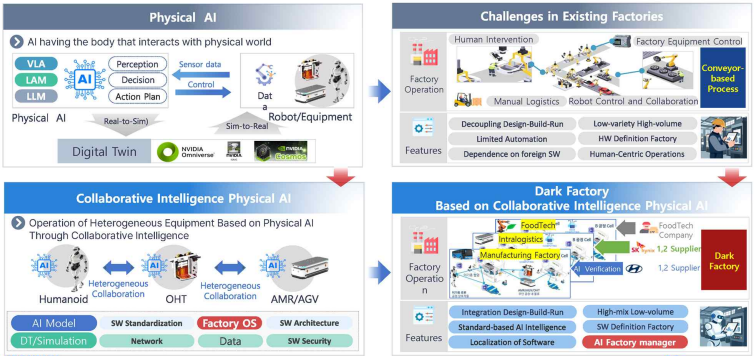
Prof. Suntae Kim
(Director of Physical AI Innovation Research Center)
Jeonbuk National University

JEONBUK NATIONAL UNIVERSITY

Physical AI Innovation Research Center

1. Key Concepts | Collaborative Intelligence Physical AI

Collaborative Intelligence Physical AI For Dark Factory



2. Project Goal | Advanced AI Factory (budget : 725M USD)

Physical AI Simulation, Factory OS(SDF-OCS), Based on Foundation Model Core Technology

Korean Collaborative Intelligence Physical AI-based Advanced AI Factory



3. Infrastructure | Collaborative Intelligence P-AI based SW Platform R&D Ecosystem Creation

KISTEP Preliminary Feasibility Study

Development of an Open Industry–Academia Integrated Research and Validation Framework

Plan for Open Physical Research Complex

I-Seo Campus of Jeonbuk National University

- (Physical AI R&D Center) Collaboration research center for Industry-academia-research collaboration
- (Physical AI Meta-Factory)
- (NPU Test Zone)



Category	R&D Center	NPU Test Bed	Meta Factory	Total
Total Floor Area	6,200㎡	3,692㎡	7,505㎡	17,397㎡
Project Cost	26.1M USD	21.7 USD	29M USD	76.8M USD

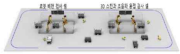
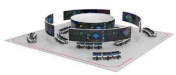
! Expectation

- **Accelerate technology adoption in the field** through validation in a real-time digital twin environment.
- **An open industry-academia-research ecosystem** for core technology development and validation

3. Infrastructure | Collaborative Intelligence P-AI based SW Platform R&D Ecosystem Creation

KISTEP Preliminary Feasibility Study

Manufacturing Physical AI Validation Testbed – 8 Zones
Total : 141.8M USD

Flexible Manufacturing Zone 14M USD	Adaptive Process Manufacturing Zone 15.6M USD	Precision Assembly Zone 11.1M USD	AI Precision Inspection Zone 12.7M USD
			
Heterogeneous In-Plant Logistics Zone 18.1M USD	**FoodTech Verification Zone** 9.8M USD	**NPU and High-Performance Computing Demonstration** 56.9M USD	**Integrated Monitoring and Control Zone** 3.6M USD
			

4. 2025 PoC Project | Industry-Specialized Physical AI Leading Model Development and PoC

Goal

(1) Design 5-Year Research Roadmap of Collaborative Intelligence Physical AI
(2) Construct Small-Scale Factory in a university,
(3) Apply Physical AI technologies into the industrial factory as a pilot.

Project Period: September 2025 ~ December 2025

Total Budget: 29M USD

Project Description

Global Network/Alliance Building

1 Planning
Physical AI Strategy Model
(Constructions, Locations)

Use of the Designed Integrated Platform

2 Designing
5-Year Research Road Map in Detail

Foundation Model | DT/Simulation | Factory OS

Use of the Technology Verification Lab and Field PoC

Use of the Technology Validation Lab and Field PoC

3 Constructing
Physical AI Labs & Industrial PoC

(Jeonbuk Nat'l Univ.) Manufacturing Physical AI Lab
(KAIST) In-Plant Logistics Physical AI Lab

Physical AI Field Application
Feedback

PoC in Industrial Factories

DH AUTOLEAD, DONGHAE

Physical AI Convergence Technology Project Group(Governance)

4. 2025 PoC Project | Designing Physical-AI Integrated SW Platform

11 R&D Plan/Roadmap

1 Manufacturing Physical AI Foundation Model
- Domain-Specific Foundation Model for Heterogeneous Collaboration-Based Physical AI
- Domain-Specific Foundation Model for Collaborative Physical AI in Unmanned Factories

2 DT/Simulation Platform Architecture
- Standard Model for Physical AI–DT Federation
- Sim-to-Real Technology Design for Physical AI-Based Collaborative Intelligence System
- AI-Based Dark Factory Design and Operation Report

3 Factory OS & Security Infrastructure
- SW Standardization and Modular SDF-OCS Design Report
- Design Report for the Demonstration of a Manufacturing-Specialized Collaborative Intelligence System
- Design Report for a Manufacturing–Logistics Integrated Test EnvironmentDesign Report for End-to-End Security of the Physical AI System

Goal

1 Defining the Direction of the Main Project

2 Risk Minimization

15 Prototypes

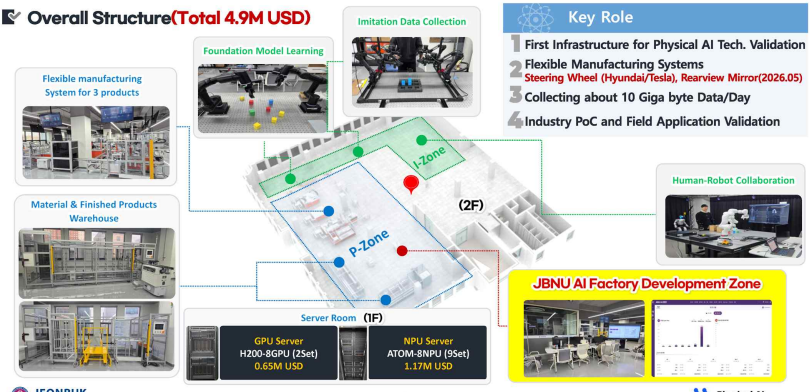
1 Manufacturing Physical AI Foundation Model Prototypes
- Three Foundation Models for Heterogeneous Collaborative Physical AI
- Four Foundation Models for Collaborative Physical AI in Unmanned Factories

2 DT·Sim-to-Real Integrated Prototypes
- One Physical AI–DT Federated Virtual Environment
- One Physical AI-Based Sim-to-Real System
- One SDF-Based Simulation and DT Integration

3 Factory Operation, Security, and Computing Infrastructure Prototypes
- One Policy-Based Decision–Execution Control
- One Physical AI-Based Intelligent Logistics Operation Technology Development and Validation
- One Integrity Verification for Full Lifecycle Security of the Physical AI System
- One Prototype of Cosmos-Transfer Based on a Domestic NPU
- One Prototype of Cosmos-Predict Based on a Domestic NPU

4. 2025 PoC Project | Manufacturing Physical-AI Tech. Validation Lab in Jeonbuk National University

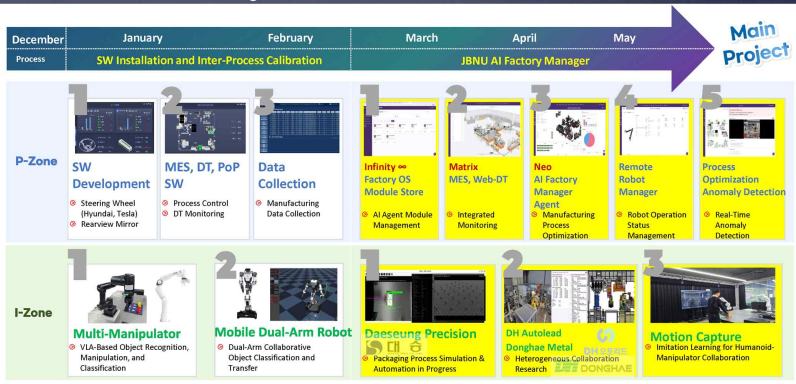
Overall Structure(Total 4.9M USD)



Key Role

1 First Infrastructure for Physical AI Tech. Validation
2 Flexible Manufacturing Systems
Steering Wheel (Hyundai/Tesla), Rearview Mirror(2026.05)
3 Collecting about 10 Giga byte Data/Day
4 Industry PoC and Field Application Validation

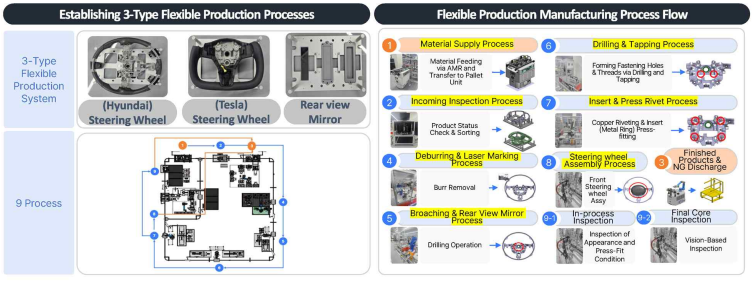
4. 2025 PoC Project | Operating Physical-AI Tech. Validation Lab



4. 2025 PoC Project | Production-Zone (Infrastructure)

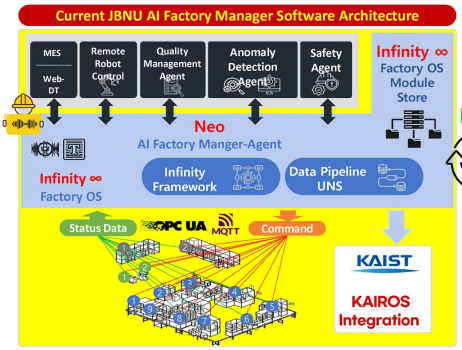
HW Infrastructure

Establishing Research & Demonstration Infrastructure for Physical AI Operating 3-Type Flexible Production with Scalability



4. 2025 PoC Project | Production-Zone (SW)

SW Infrastructure (Under Research)



FeedBack

Apply

Advancement

1. Factory-Specific Factory OS
2. Factory DT Simulation
3. AI-Based Predictive Maintenance and Asset Management
4. Autonomous Quality Management
5. Integrated Robot Fleet Orchestration
6. Autonomous AI Decision-Making
7. Adaptive Supply Chain Optimization
8. Cybersecurity and Governance
9. Unmanned Factory / Heterogeneous Collaboration FM

4. 2025 PoC Project | Industry-Specialized Physical AI Leading Model Development and PoC

DH AUTOLEAD - [Product] Automotive Steering



Human-Centered Operation ➡ Implementation of DT-Optimized Unmanned Automation



AS-IS



TO-BE

AMR-Based Material Transfer



Automated Operations



Improvement Achievements Through PoC Support

20% Increase in Productivity ➡ Plan to invest 30.9M USD For Dark Factory by 2028

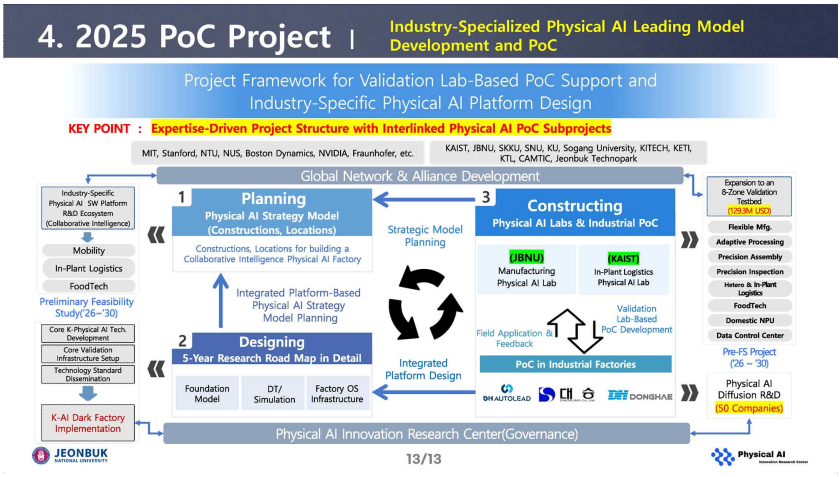
Collaboration with JBNU

Process / Data / Quality

1. Improvement of Heterogeneous Equipment Collaboration Efficiency Based on Process Data
2. Quality Issues → Process Data-Based Root Cause Analysis

※ Physical AI Validation for Flexible Production → Expansion to Assembly Automation
※ Applying AMR Virtual Environment Learning Data to Factory Operations

※ Physical AI-Based Equipment Simulation → Autonomous Action


4. 2025 PoC Project | Industry-Specialized Physical AI Leading Model Development and PoC
Project Framework for Validation Lab-Based PoC Support and Industry-Specific Physical AI Platform Design
KEY POINT : Expertise-Driven Project Structure with Interlinked Physical AI PoC Subprojects
MIT, Stanford, NTU, NUS, Boston Dynamics, NVIDIA, Fraunhofer, etc.
KAIST, JBNU, SKKU, SNU, KU, Sogang University, KITECH, KETI, KTL, CAMTIC, Jeonbuk Technopark
Global Network & Alliance Development
Industry-Specific Physical AI SW Platform R&D Ecosystem (Collaborative Intelligence)
Mobility
In-Plant Logistics
FoodTech
Preliminary Feasibility Study('26~'30)
Core K-Physical AI Tech. Development
Core Validation Infrastructure Setup
Technology Standard Dissemination
K-AI Dark Factory Implementation
1 Planning
Physical AI Strategy Model (Constructions, Locations)
Constructions, Locations for building a Collaborative Intelligence Physical AI Factory
Integrated Platform-Based Physical AI Strategy Model Planning
2 Designing
5-Year Research Road Map in Detail
Foundation Model
DT/ Simulation
Factory OS Infrastructure
Strategic Model Planning
Integrated Platform Design
3 Constructing
Physical AI Labs & Industrial PoC
(JBNU) Manufacturing Physical AI Lab
(KAIST) In-Plant Logistics Physical AI Lab
Field Application & Feedback
Validation Lab-Based PoC Development
PoC in Industrial Factories
DH AUTOLEAD
DONGHAB
Expansion to an 8-Zone Validation Testbed (129.3M USD)
Flexible Mfg.
Adaptive Processing
Precision Assembly
Precision Inspection
Hetero & In-Plant Logistics
FoodTech
Domestic NPU
Data Control Center
Pre-FS Project (26 ~ 30)
Physical AI Diffusion R&D (50 Companies)
Physical AI Innovation Research Center(Governance)
JEONBUK NATIONAL UNIVERSITY
Physical AI
13/13


Thank you.

CHALLENGES AND OPPORTUNITIES IN HYBRID ADDITIVE MANUFACTURING FOR FUNCTIONAL MATERIALS
기능성 소재를 위한 하이브리드 적층제조의 도전과 기회

M.P. Sealy*, L. Sotelo, K.L.M. Avegnon, R. Karunakaran, Y. Mittal, H. Hadidi, G. Madireddy, R. Henry, B. Vieille, M. Titus

Speaker: Michael Sealy

1. Associate Professor, School of Mechanical Eng., Purdue University, USA

JEONBUK NATIONAL UNIVERSITY

Hosts: Kyung-Soo Kook & Martin Jun
Date: 06/12/2026

PURDUE UNIVERSITY | School of Mechanical Engineering
INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES ROUEN NORMANDIE
GPM Groupe de Physique des Matériaux
MMRL MANUFACTURING & MATERIALS RESEARCH LABORATORIES

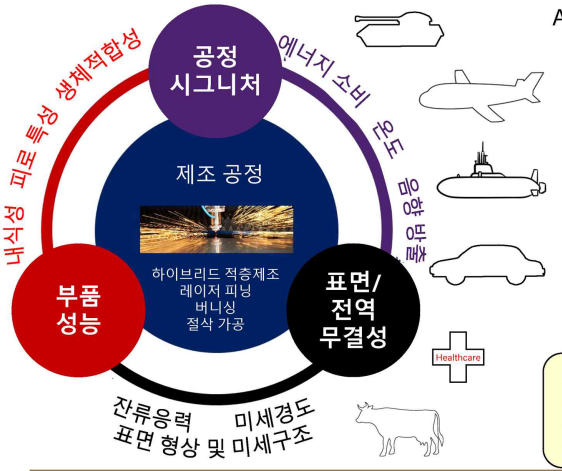


레이저 가공 제조 적층제조 INSA ROUEN NORMANDIE 3D 프린팅 마그네슘 충격 저항성
하이브리드 제조 University of Nebraska Lincoln SURFACE INTEGRITY Creating an Orthopedic Revolution 생분해성 임플란트 부식 금속
학술 도제제도 세포농업 배양육 지속가능성 피로 고분자
공학 기업가정신



연구 배경

연구 중점 분야
- 하이브리드 적층제조
- 배양육 적층제조

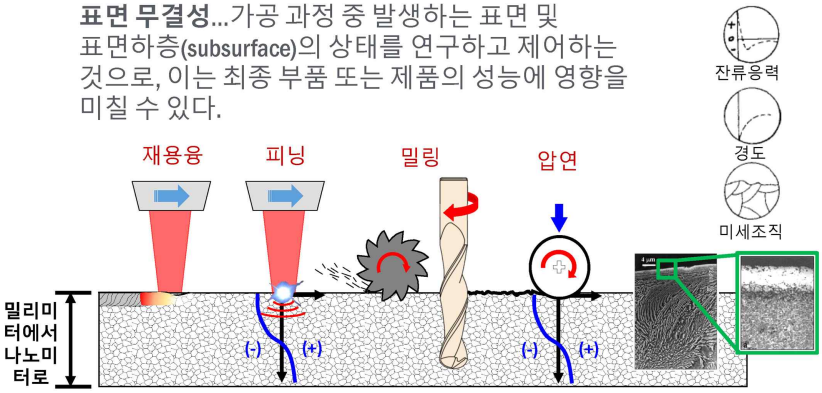


Applications
- 우주 공간 내 제조
- 달 및 화성 환경 활용
- 마그네슘 적층제조 및 내식성 향상
- 왜곡(변형) 저감
- 고탄성 메타폴리머 복합재
- 충격/에너지 흡수
- 경량화
- 내마모성
- 방사선 저항성
- 자율주행 도시형 차량; 고속 단거리 빈번 비행 항공기

연구 공백
- 하이브리드 적층제조 설계
- CAD/CAM/CAE 도구
- 측정 과학(계측 기술)

전통적 제조 공정 플랫폼

표면 무결성...가공 과정 중 발생하는 표면 및 표면하층(subsurface)의 상태를 연구하고 제어하는 것으로, 이는 최종 부품 또는 제품의 성능에 영향을 미칠 수 있다.



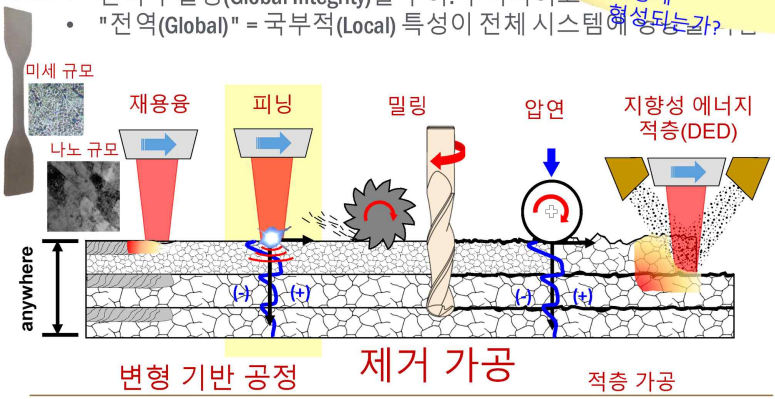
Groover, Manufacturing Processes, 2015

하이브리드 적층제조 (Hybrid AM) 공정

핵심 연구 질문
- 기계적 특성을 제어(설계)할 수 있다면 어떨까?
- 전역 무결성은 어떻게 형성되는가?

다중 공정 비동기 하이브리드 적층제조

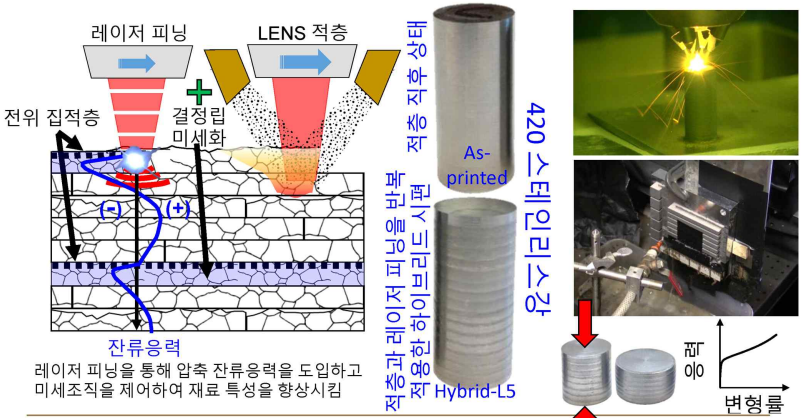
- 전역 무결성(Global Integrity)을 부여: 누적적이고 [illegible]성
- "전역(Global)" = 국부적(Local) 특성이 전체 시스템에 영향을 [illegible]



접근 방법

Sealy, 2019, CIRP Annals

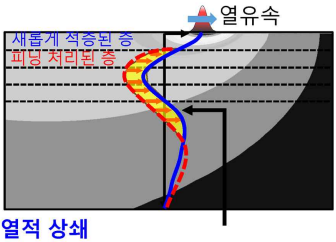
하이브리드 적층제조: 반복적 LENS 프린팅과 레이저 피닝

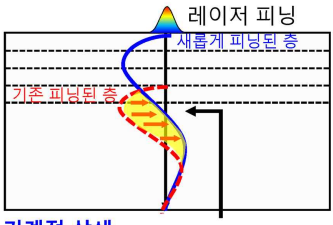


복잡한 계면(Interface)에 대한 지식 공백

(1/3)

열적 및 기계적 재분포

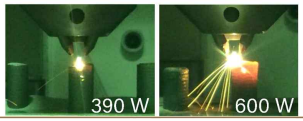




열적 상쇄
이전에 피닝 처리된 층에 새로운 적층이 이루어질 때 가해지는 열유속으로 인해 잔류응력이 상쇄(완화)되는 현상

기계적 상쇄
새롭게 피닝된 층에 의해 기존 층의 압축 잔류응력이 감소하거나 상쇄되는 현상

(적층 출력 조건에 따른 열적 영향 비교)

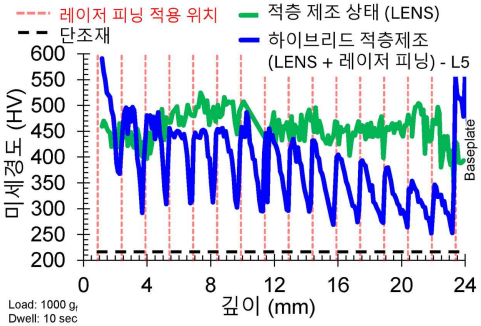


Electric?....Magnetic?

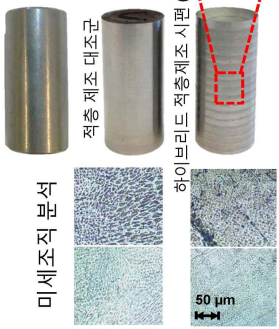
Sealy et al., 2019, CIRP Annals
Sealy et al., 2019, Nanotech & Precision Eng.
Sealy et al., 2020, CIRP Annals
Sealy et al., 2024, CIRP Annals
Avegnon et a., 2026, Scripta Materialia

결과

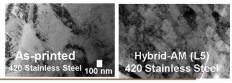
하이브리드 적층제조: 반복적 LENS 프린팅과 레이어 피닝







나노 스케일 분석

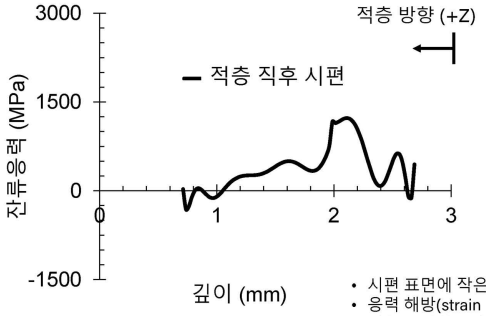


Sealy, 2019, CIRP Annals

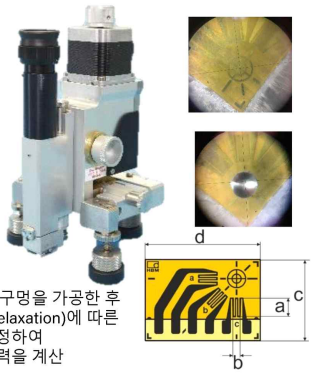
결과

하이브리드 적층제조: 반복적 LENS 프린팅과 레이저 피닝

420 스테인리스강의 잔류응력 분포



ASTM E837 홀 드릴링(Hole Drilling) 방법



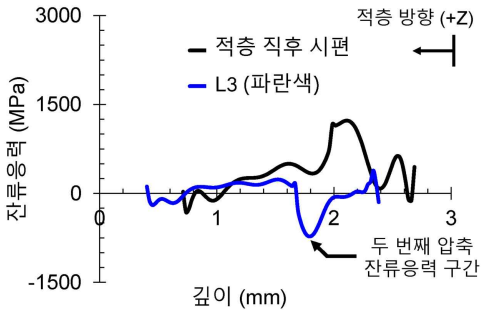
- 시편 표면에 작은 구멍을 가공한 후
- 응력 해방(strain relaxation)에 따른 변형률 변화를 측정하여
- 깊이 방향 잔류응력을 계산

Sealy, 2019, CIRP Annals

결과

하이브리드 적층제조: 반복적 LENS 프린팅과 레이저 피닝

420 스테인리스강의 잔류응력 분포



재료
- 420 스테인리스강
- 마그네슘 WE43
- Ti-6Al-4V
- AlSi10Mg

잔류응력 측정 방법
- 홀 드릴링
- 중성자 회절
- 초음파법

적층제조 공정
- LENS
- PBF

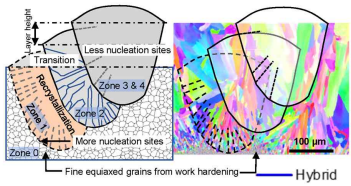
LENS 적층 과정의 후속 열사이클에 의해 피닝으로 형성된 유리한 압축 잔류응력이 열적으로 상쇄되지 않았다.

Sealy, 2019, CIRP Annals

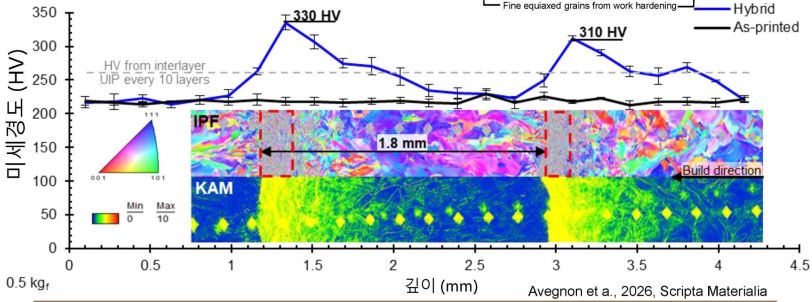
결과

하이브리드 적층제조:

반복적 PBF 적층 및 초음파 피닝

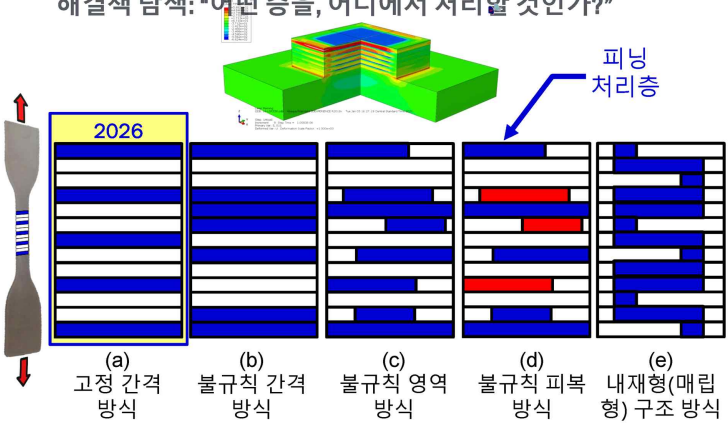


10개 적층층마다 층간 초음파 피닝(UP) 적용



복잡한 계면(Interface)에 대한 지식 공백 (2/3)

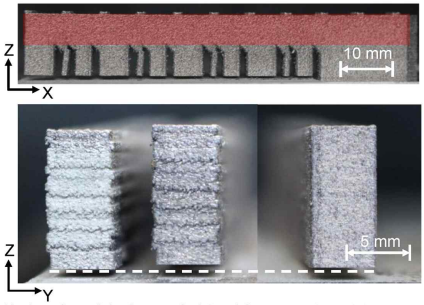
해결책 탐색: "어떤 층을, 어디에서 처리할 것인가?"



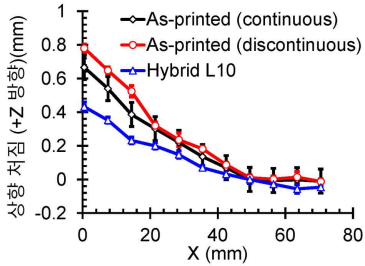
결과

NIST 브리지의 변형(처짐) 거동 (PBF 및 레이저 피닝 적용)

- Hybrid L10 브리지 시편은
  - 대조군(Control) 대비 45% 낮은 변형(distortion) 을 나타냄.
  - 연속 적층 시편(Continuous Printing) 대비 35% 낮은 변형을 나타냄.



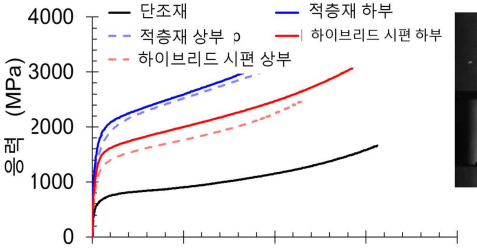
하이브리드 적층제조 + 레이저 피닝 | 비연속 적층 시편 | 연속 적층 시편

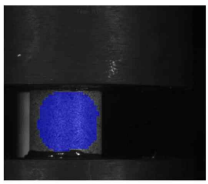


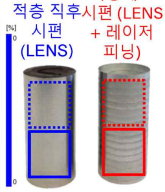
Madireddy et al., 2021, ISEM

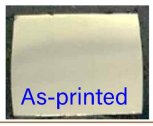
결과

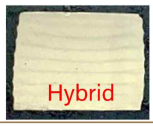
준정적 압축 시험: 420 스테인리스강 (LENS 적층 및 레이저 피닝)









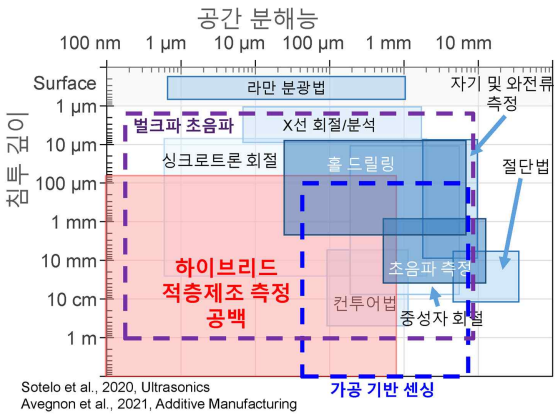




Sealy et al., 2020, CIRP Annals

복잡한 계면(Interface)에 대한 지식 공백 (3/3)

하이브리드 적층제조에서 발생하는 변화를 어떻게 측정할 것인가?



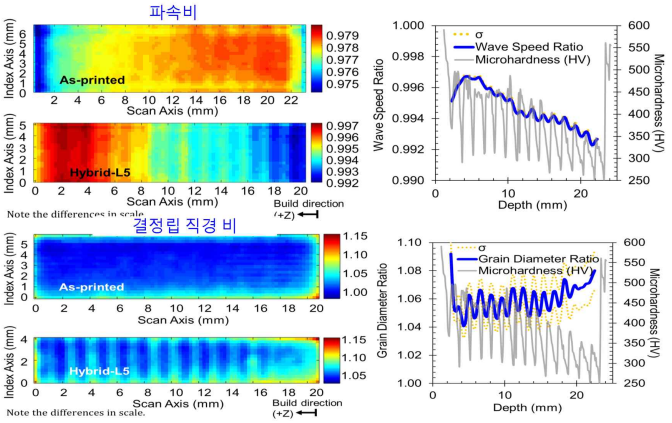


Sotelo et al., 2020, Ultrasonics
Avegnon et al., 2021, Additive Manufacturing

*Modified from Shajer, Residual Stress Measurement

잔류응력 및 미세조직 측정

초음파를 이용한 계면 측정 (잔류응력 및 결정립 크기)

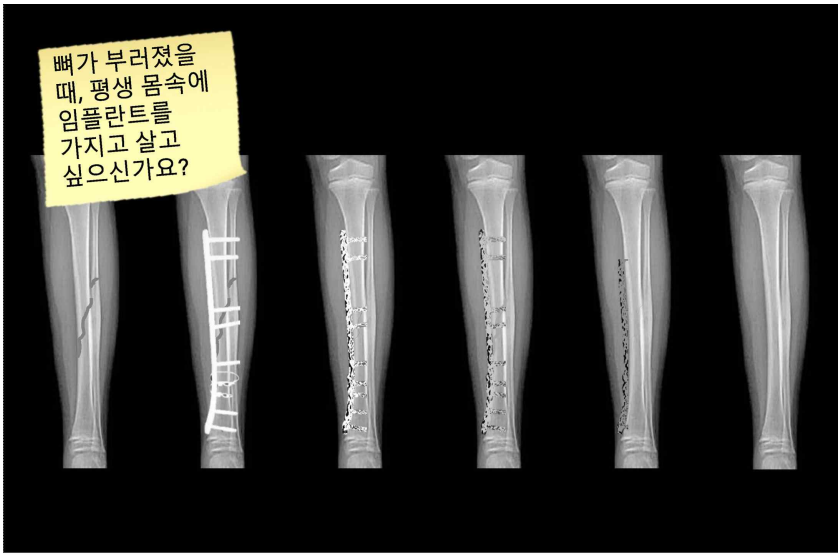


Sealy et al., 2020, CIRP Annals
Collaboration with Turner and Sotelo (UNL)

DIGITAL MAYHAM

A better way to make everything







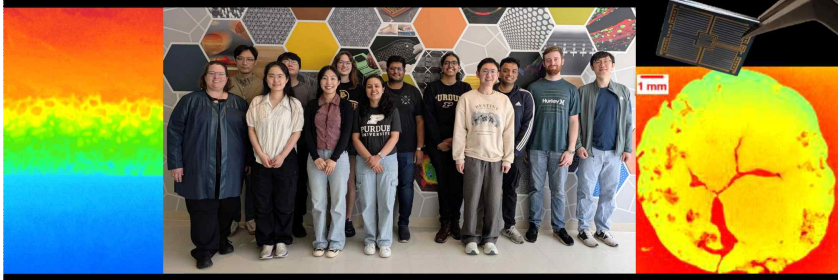
Elon Musk's SpaceX Falcon Heavy Rocket launches Tesla Car into Space, Feb. 6, 2018

감사합니다

Michael Sealy, Ph.D.
School of Mechanical Engineering
Purdue University
msealy@purdue.edu
256.702.5031



Thermal Engineering to Enable Next Generation Devices



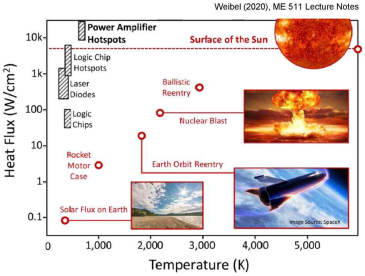
Cooling Technologies Research Center

Amy Marconnet
Mechanical Engineering
marconnet@purdue.edu
engineering.purdue.edu/MTEC

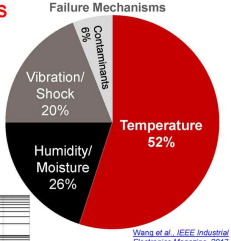
PURDUE UNIVERSITY

Thermal Challenges in Electronic Devices

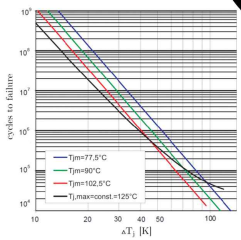
Increasing Heat Fluxes Demand New Cooling Solutions



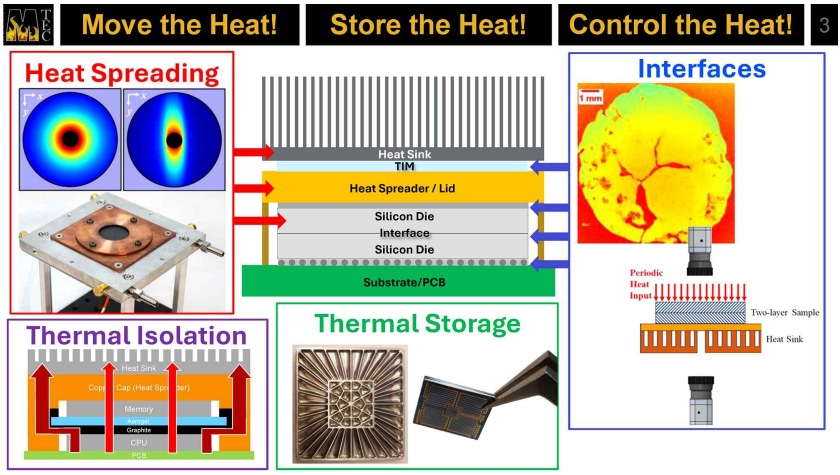
Temperature Rises are a Leading Cause of Failure for Electronic Devices

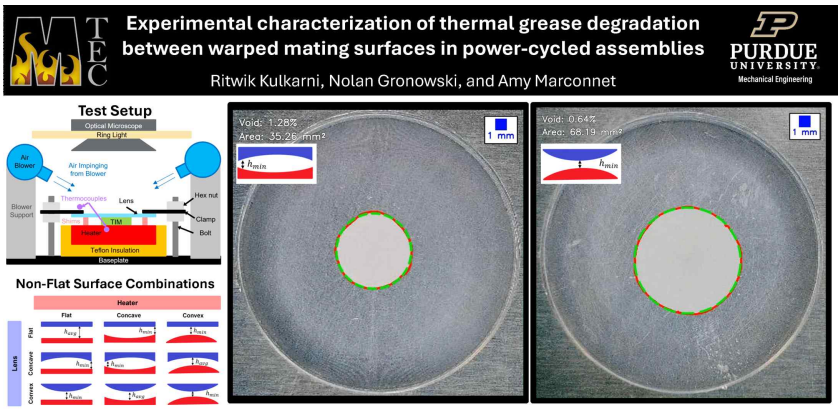


Wang et al., IEEE Industrial Electronics Magazine, 2017



Andersen et al., IEEE Transactions on Power Electronics, 2017





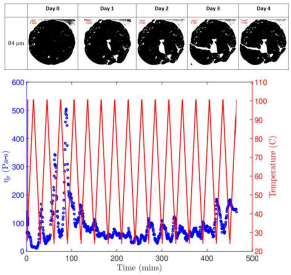
Kulkarni *et al.*, *Applied Thermal Engineering*, 2026.
DOI: 10.1016/j.applthermaleng.2026.129742
Data: https://purr.purdue.edu/publications/4958/1

SCALE
SCalable Asymmetric Lifecycle Engagement

COOLING TECHNOLOGIES RESEARCH CENTER

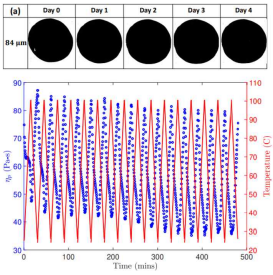
Degradation & Rheological Characterization

TIM-1



- Non-repeatable viscosity variation
- Microstructure breakage after first few cycles
- Unstable to thermal stresses
- Observed void formation and radial spreading

TIM-2

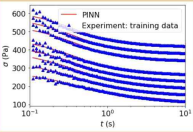


- Repeatable viscosity variation
- Stable microstructure
- Stable to thermal stresses

η_p: Dynamic Viscosity

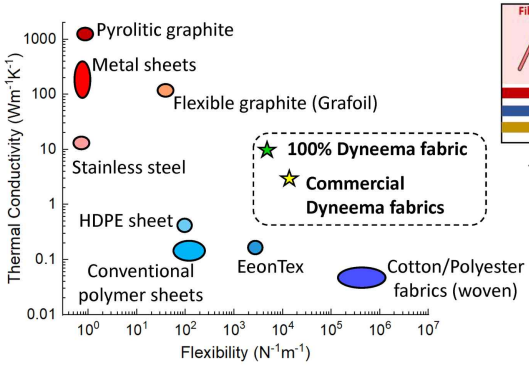
Collaboration with Prof. Kendra Erk (MSE @ Purdue)

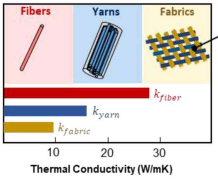
"Data-driven rheological characterization of stress buildup and relaxation in thermal greases" by Nagrani *et al. JOR*, 2023.
https://arxiv.org/abs/2304.12104
doi: 10.1122/8.0000679

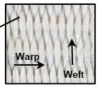


Use ML to learn unknown parameters within the models that describe the rheology of TIMs

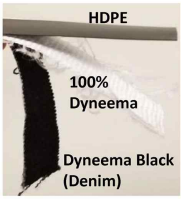
Multi-Functional Properties







Candadai, Weibel, Marconnet, *ACS App. Polym. Mater.* 2020

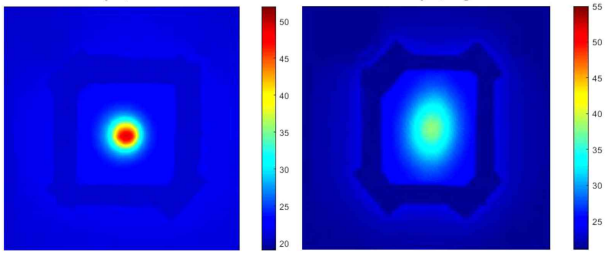


Cooling Technologies Research Center

Candadai *et al. ACS Applied Polymer Materials*, 2020.

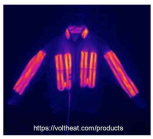
In Plane Thermal Conductivity of Packaging Materials

Isotropic, low k | Anisotropic, high k



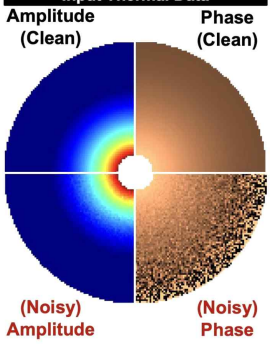
- Characterize and optimize material properties for composite heat spreaders
- Integrate flexible high conductivity heat spreaders into wearable electronics or situations needing conformal heat spreading





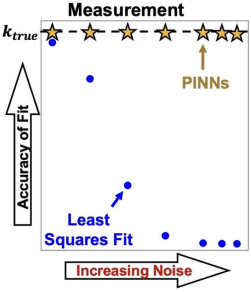
Machine Learning for Robust Parameter Extraction

Input Thermal Data



Accuracy of Extracted k

PINNs Enable Robust Extraction of k from a Noisy Measurement



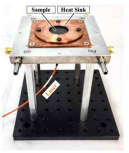
Sripada *et al.*, "Robust inverse parameter fitting of thermal properties from the laser-based Ångstrom method in the presence of measurement noise using physics-informed neural networks (PINNs)", *Journal of Applied Physics*, 2024. DOI: 10.1063/5.0206247



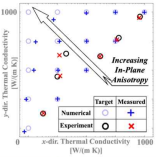
Shanmukhi Sripada
QualComm
Intern this summer

Advanced Thermal Metrology

2D Laser Ångstrom Method Experimental Facility



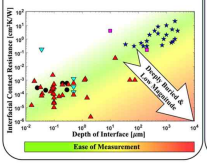
Broad Range & Accuracy of Measured k_x & k_y



Range and Accuracy of In-Plane Anisotropic Thermal Conductivity Measurement using the Laser-based Angstrom Method
A.U. Gaitonde, J.A. Weibel, and A.M. Marconnet, *Review of Scientific Instruments*, 96, 014903, 2025.
DOI: 10.1063/5.0238285

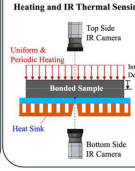
Thermal Metrology for Deeply Buried Low-Thermal-Resistance Interfaces
A.U. Gaitonde, J.A. Weibel, and A.M. Marconnet, *International Journal of Heat and Mass Transfer*, vol. 241, 126591, 2025.
DOI: 10.1016/j.ijheatmasstransfer.2024.126591

Limited Tools for Characterizing Deeply Buried and Low Thermal Resistance Interfaces (R_{th})

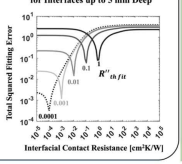


This Work: Metrology for Deeply Buried Thermal Interfaces

Simultaneous Periodic Laser Heating and IR Thermal Sensing



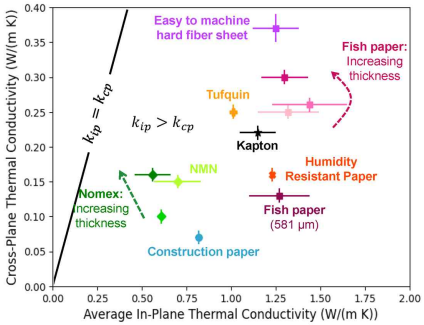
Accurately Extracts R_{th} O(10^{-4}) cm²K/W for Interfaces up to 5 mm Deep

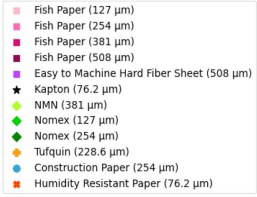


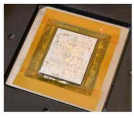
Metrology for Very-Low Thermal Resistance TIMs

Objective: Develop, design, and validate a plug-and-play measurement technique to quantify thermal resistances of TIMs with $R''_{th} \leq 1$ mm²K/W (0.01 cm²K/W)

Thermal Properties of Electrically Insulating Sheets







Kapton Tape on a GPU

Sripada *et al.*, *Thermal Characterization of Contemporary Electrical Insulation Materials*, *ITherm* 2024

Cooling Technologies Research Center

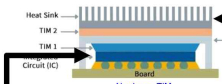
THERMAL ENERGY STORAGE FOR THERMAL MANAGEMENT

Thermal Energy Storage with PCMs works best for transient processes:
Store energy through melting during heating. Release and resolidify at a later time.

Low-Power Microscale Integration



Apple introduces iPhone 14



Nordson - TIM

- Low power profiles: 6-15 W spread over ~1 cm^2.
- Limited PCM volume due to spatial constraints.

High-Power Macroscale Integration



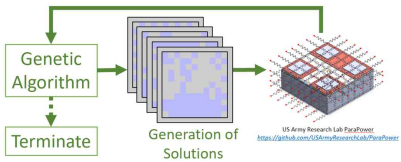
Nova LFSE+

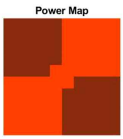
- Volatile power profiles: >1000 W spread over 3.5 cm^2.
- Requires large PCM volumes and thermal conductivity enhancements.

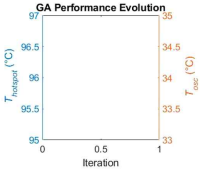
EMBEDDED PCM THERMAL MANAGEMENT

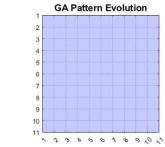
COOLING TECHNOLOGIES RESEARCH CENTER

Machine-Learning Aided Optimization:

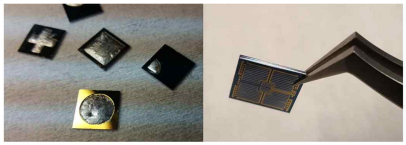








Experimental Evaluation:

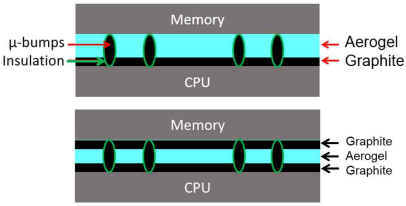


References: Bhatasana & Marconnet, "Optimization of an Embedded Phase Change Material Cooling Strategy Using Machine Learning", *ITherm 2021*
Bhatasana & Marconnet, "Machine-Learning Assisted Optimization Strategies for Phase Change Materials Embedded within Electronic Packages", *Applied Thermal Engineering*, 2021.
Bhatasana& Marconnet, *Electronics Cooling Magazine*, http://bit.ly/EmbeddedCooling

bit.ly/MTEC_ML
bit.ly/MTEC_ML2
bit.ly/MTEC_ML3

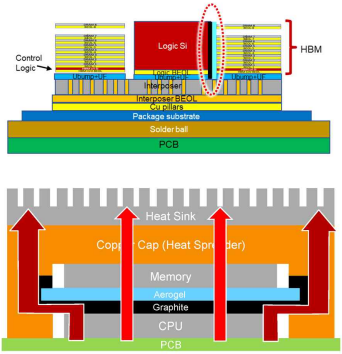
Design Concept: Composite Heat Spreader

Bi-/Tri-Layer Heat Spreader

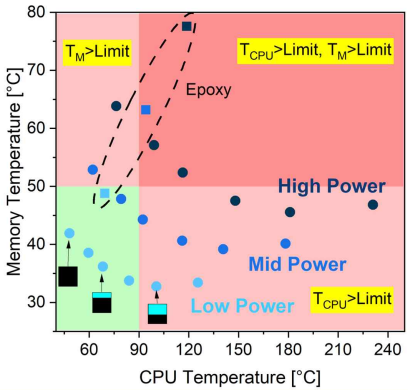


- Graphite layer with high in-plane thermal conductivity spreads heat generated from local hot spot.
- Aerogel layer with low thermal conductivity block heat transfer (thermal cross-talk) between memory and logic die.

Implementation of Bi-Layer Structure

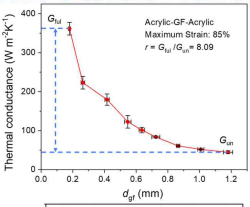


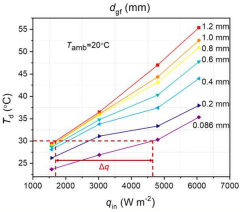
Performance of the Bi-Layer at Different Power Levels

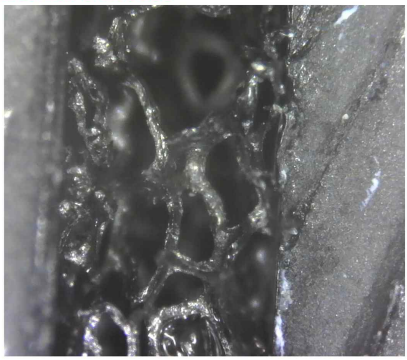


- At a low power level, the bi-layer has a large tuning range for layer thicknesses, and the epoxy case is within safe operation limits.
- The 3D package configuration benefits the most from the bi-layer at a medium power level.
- More cooling power is required for the CPU to operate at higher power levels.

Flexible Graphene Foam-Based Thermal Switches



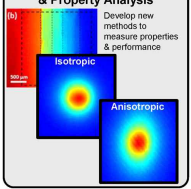




Du & **Xiong** *et al. Nat. Comm.* **12**, 4951 (2021).

Marconnet Thermal & Energy Conversion (MTEC) Lab: Semiconductor Research 16

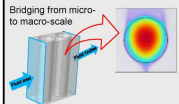
Metrology Development & Property Analysis



Develop new methods to measure properties & performance

Fundamental Transport Analysis & Multi-Scale Modeling

Bridging from micro- to macro-scale



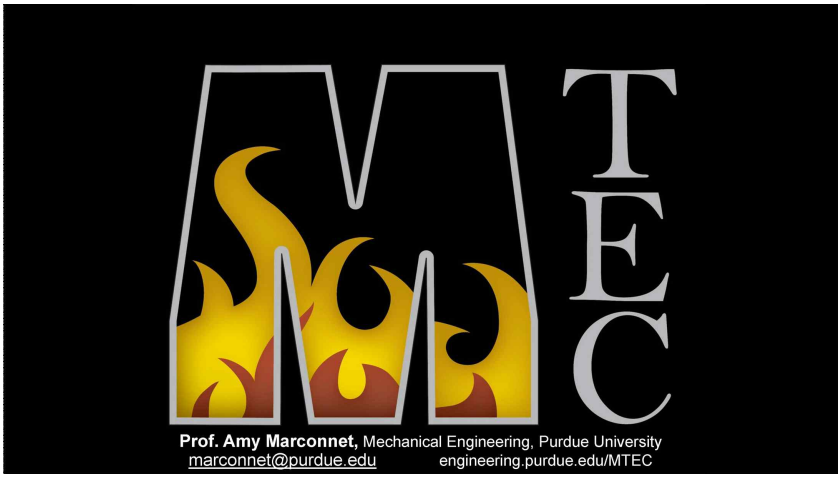
Coupled Physics: Thermal + Fluids + Electrochemical + Mechanics + …

Physics-Informed Design of Materials, Devices, and Systems

Move the Heat

Transport Across Interfaces


Boron Nitride
Graphene
Silicon
Gallium Nitride
Diamond
Molybdenum Disulfide
Tungsten Diselenide
Gold
Silicon Dioxide
Aluminum Oxide
Tungsten
Titanium
Indium Tin Oxide
Aluminum Nitride
Hafnium Oxide
Magnesium Oxide
Zinc Oxide
Titanium Dioxide
Niobium Pentoxide
Tantalum Pentoxide
Lead Zirconium Titanate
Barium Titanate
Strontium Titanate
Lithium Niobate
Lithium Tantalate
Potassium Niobate
Potassium Tantalate
Bismuth Ferrite
Lanthanum Aluminate
Lanthanum Gallate
Neodymium Gallate
Scandium Magnesium Aluminate
Strontium Ruthenate
Yttrium Aluminum Garnet
Yttrium Iron Garnet
Gadolinium Gallium Garnet
Neodymium Iron Garnet
Yttrium Barium Copper Oxide
Lanthanum Strontium Manganite
Lanthanum Strontium Cobaltite
Lanthanum Strontium Cuprate
Lanthanum Strontium Ferrite
Lanthanum Strontium Chromite
Lanthanum Strontium Titanate
Lanthanum Strontium Vanadate
Lanthanum Strontium Nickelate
Lanthanum Strontium Ruthenate


MTEC
Prof. Amy Marconnet, Mechanical Engineering, Purdue University
marconnet@purdue.edu
engineering.purdue.edu/MTEC

2026 1st JPRI INTERNATIONAL Conference

(JBNU–Purdue Research Institute)



JPRI
JBNU–Purdue Research Institute

JEONBUK
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UNIVERSITY

SESSION II

1. **Spatial AI and Robotics: From 3D Perception to Autonomous Action**
   HyungGi Jo, Jeonbuk National University
2. **Smart Steering Wheel as the Next AI-Based Human-Machine Interface**
   Jongsik Bae, Vice President, DH Group
3. **Nondestructive Evaluation for Advanced Manufacturing**
   Luz Sotelo, Purdue University
4. **AI-Driven Warfare and Rapid Acquisition: Implications for Korea-U.S. Defense Cooperation**
   Won Joon Jang, Jeonbuk National University

JEONBUK NATIONAL UNIVERSITY

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Jeonbuk National Univ.

Spatial AI and Robotics: From 3D Perception to Autonomous Action

Research Presentations

2026.06.
조형기
AI Robotics Lab.
Jeonbuk National Univ.

AI Robotics Lab

Introduction

Profile

조형기 (HYUNGGI JO)

EDUCATION

- B.S. Dept. of Electrical and Electronic Engineering, Yonsei Univ.
- Ph.D. Dept. of Electrical and Electronic Engineering, Yonsei Univ. (Advisor: Prof. Euntai Kim)

CAREER

- 2025 ~ : Associate Professor, Dept. of Electronic Engineering, Jeonbuk National Univ.
- 2021 ~ 2024 : Assistant Professor, Dept. of Electronic Engineering, Jeonbuk National Univ.
- 2020 ~ 2021 : Senior Researcher, Intelligent Robotics Research Center, Korea Electronic Technology Institute (KETI)

RESEARCH INTERESTS

- Perception for Intelligent Robots, Spatial AI
- Sensor Fusion, Mobility, SLAM
- Multi-Robot System

- Web https://airlab.jbnu.ac.kr
- Youtube www.youtube.com/@airlab-jbnu
- Notion http://airlab-jbnu.notion.site

Contents

1. Spatial AI
Visual Localization
SLAM

2. Intelligent Robotic Systems
Robot Foundation Model
Human-Robot Interaction

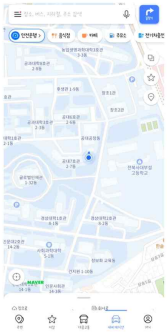
Spatial AI

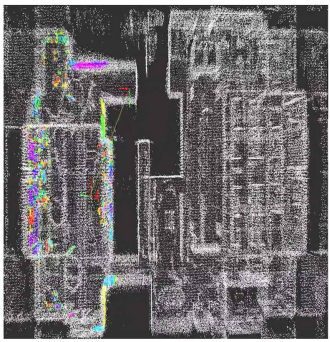
Spatial AI

Perception of Space

- Semantics
- Mapping
- Pose Tracking

A Map is given





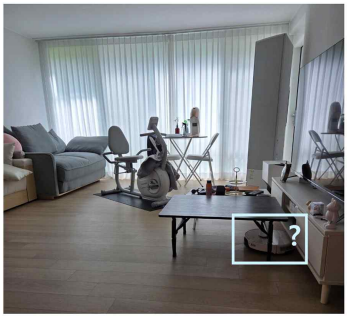
Spatial AI

Perception of Space

- Semantics
- Mapping
- Pose Tracking

Simultaneous Localization And Mapping (SLAM)





Spatial AI

Perception of Space

Semantics
Mapping
Pose Tracking

+ Semantic Info.









Visual Localization

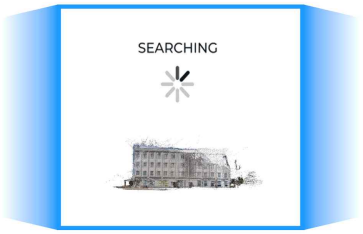
Definition

"Visual Localization is the ability to **localize** an agent's position using **images as input.**"



Where am I?





Position Estimation can be:

1. 6DoF Pose
2. 3DoF Pose
3. GPS Coordinates, etc.



Visual Localization

Methods

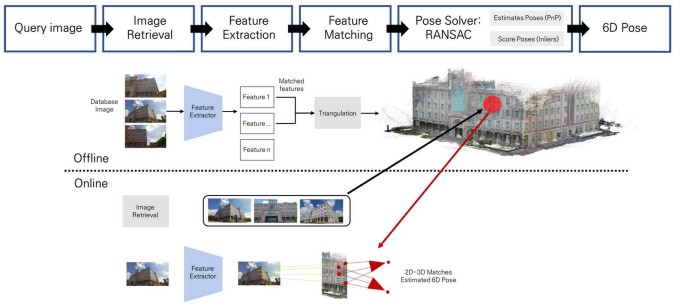
Visual localization is divided into several methods:

0. Retrieval method (still debatable whether it's included in the visual localization method or not)
1. Feature-based
2. Regression-based

Visual Localization Methods

Feature-based method

"Find the features, match the scene."



Pros and Cons

Feature-based method

Pros and Cons

- Very accurate; the most accurate among the visual localization methods
- Extensive memory; saving the descriptor and the pre-built map
- Multiple stages, long mapping time

Related Work

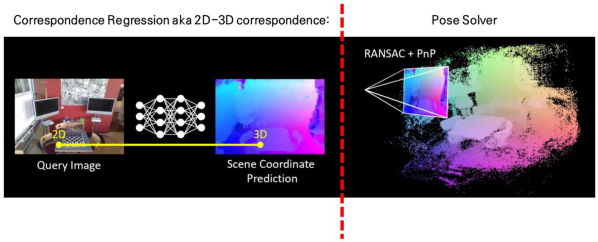
- HLOC: "From Coarse to Fine: Robust Hierarchical Localization at Large Scale", Sarlin et al., CVPR'19
- SuperPoint: "SuperPoint: Self-Supervised Interest Point Detection and Description", DeTone et al., CVPR Workshops'18
- SuperGlue: "SuperGlue: Learning Feature Matching with Graph Neural Networks", Sarlin et al., CVPR'20
- NetVLAD: "NetVLAD: CNN architecture for weakly supervised place recognition", Arandjelovic et al., CVPR'16

Scene Coordinate Regression

Learning-based Method

Standard SCR framework

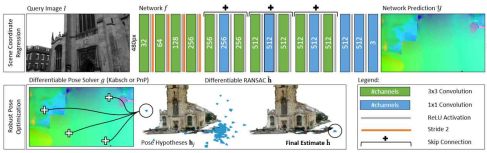




Scene Coordinate Regression Forests for Camera Relocalizationin RGB-D Images, Shottonet al., CVPR'13

Scene Coordinate Regression

Problems





★ Important region

✱ Non-important region

Pros and Cons:

- Smaller map
- Better accuracy than other regression-based
- Accuracy is lower than the feature-based method
- **Regress all areas of the image, instead of regressing only the important area.**

Scene Coordinate Regression

Enhancing the SCR ability

"Let's focus on the important part only."

Previous Sampling Method's Problem

Using a 3D map or segmentation image as a sampling guidance

↓

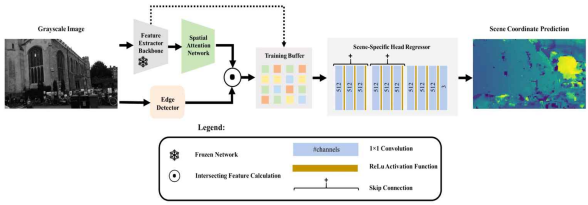
Need additional data to help the sampling process

Our Goal

Regress the 2D-3D correspondence using only essential features (features in important regions), relying solely on the contextual information from the image.

Spatial Attention and Edge Context [2025]

Our proposed method [*]



Contribution part:

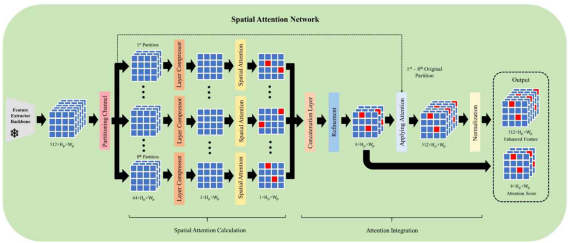
1. Spatial Attention Network
2. Feature Selector (Intersected feature of the spatial attention network and edge context)

[*] Istighfarin, Nanda Febri, and HyungGi Jo. "Leveraging spatial attention and edge context for optimized feature selection in visual localization." International Journal of Control, Automation and Systems 23.2 (2025): 418-428.

Spatial Attention and Edge Context [2025]

Our proposed method [*]

Proposed Spatial Attention Network



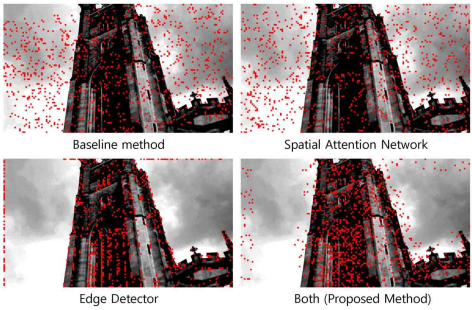
1. Spatial Attention Calculation
   Calculating the attention score for every partition made
2. Attention Integration
   Integrate scores of every partition and apply them to the original feature map.

Output:
Enhanced Feature and
Final Attention Score

[*] Istighfarin, Nanda Febri, and HyungGi Jo. "Leveraging spatial attention and edge context for optimized feature selection in visual localization." International Journal of Control, Automation and Systems 23.2 (2025): 418-428.

Spatial Attention and Edge Context [2025]

Experiment 1: Feature Selection Result and Comparison



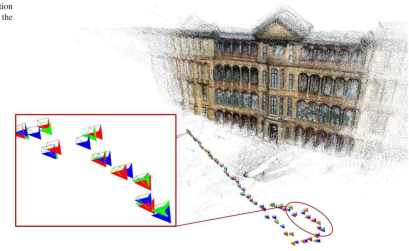
Spatial Attention and Edge Context [2025]

Experiment 2: Localization Result in Cambridge Dataset

Localization results on Cambridge Landmarks. We report the median rotation error (in degrees) and translation error (in centimeters) for every method. In the SCR group, **bold** represents the best result, and underline is the second-best result.

		Mapping Time	Mapping Size	Cambridge			
				St. Mary	Shop	Hospital	College
FM	NetVLAD [16] + HLOC [2] [15]	~1.5h	~1.8GB	0.3 / 8.9	0.2 / 4.2	0.4 / 20.3	0.2 / 13.1
	APGeM [36] + R2D2 [12]		~2.2GB	0.3 / 9.9	0.2 / 4.1	0.3 / 17.5	0.2 / 12.7
	pixLoc [37]		~1GB	0.3 / 10	0.2 / 5	0.3 / 16	0.2 / 14
APR	PoseNet [6]	~24h	~50MB	3.3 / 157	3.8 / 88	3.3 / 320	1.0 / 88
	MS-Transformer [26]	~7h	~18MB	4.0 / 162	3.1 / 86	2.4 / 181	1.5 / 83
SCR	DSAC* [32]	15.5h	27.5MB	**0.4 / 12.3**	**0.2 / 5.1**	**0.5 / 21.9**	**0.3 / 15.7**
	ACE [9]	255s	4.2MB	0.7 / 22.5	0.3 / 5.7	0.6 / 29.1	0.4 / 28.1
	Ours	242s	5.3MB	0.5 / 17.4	0.3 / 5.2	0.5 / 27.4	0.4 / 24.7

1. Our proposed network is faster
2. DSAC* still achieve the best result

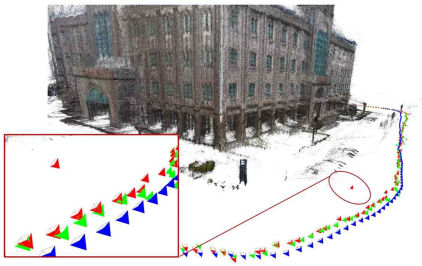


Spatial Attention and Edge Context [2025]

Experiment 3: Localization Result in JBNU Dataset

Localization results on JBNU. We report the median rotation error (in degrees) and translation error (in meters) for every method. Additionally, we implement an ensemble model for potential models within the SCR group. In the SCR and ensemble group, **bold** represents the best result, and underline is the second-best result.

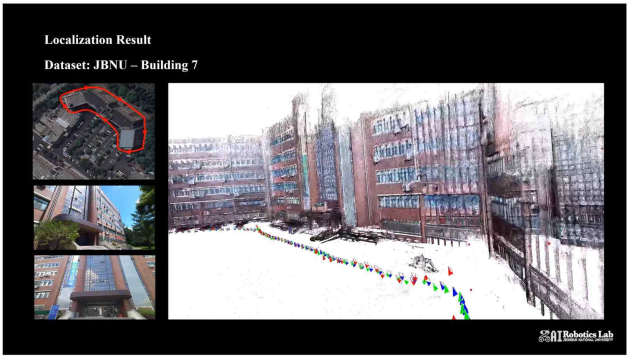
		Mapping Size	JBNU			
			Library	Building 7	Six-to-Seven	Seven-to-Six
FM	NetVLAD [16] + R2D2 [12]	~2.1GB	1.1 / 2.319	2.8 / 1.091	2.4 / 1.800	0.9 / 0.892
	APGeM [36] + HLOC [2] [15]	~2.8GB	1.1 / 2.318	2.7 / 1.105	2.1 / 1.646	1.0 / 0.890
SCR	DSAC* [32]	27.5MB	1.9 / 5.001	**3.3 / 1.632**	2.2 / 2.665	1.3 / 0.953
	ACE [9]	4.2MB	2.0 / 3.933	7.8 / 2.287	1.9 / 2.009	1.1 / 0.732
	FocusTune (with dummy 3D map) [38]	4.2MB	2.8 / 5.839	7.1 / 2.504	2.2 / 1.694	1.1 / 0.818
	Ours	5.3MB	**2.0 / 3.852**	8.2 / 2.889	**1.7 / 1.899**	**1.0 / 0.657**
Ensemble	ACE [9]	16.8MB	0.6 / 2.151	2.5 / 1.040	1.5 / 1.825	1.1 / 0.600
	FocusTune (with dummy 3D map) [38]	16.8MB	1.2 / 2.104	2.9 / 1.061	1.5 / 1.760	1.1 / 0.666
	Ours	21.2MB	**0.6 / 2.095**	**2.2 / 1.038**	**1.4 / 1.809**	**1.1 / 0.598**



1. Our proposed network perform best, whether in a single network or ensemble network

Spatial Attention and Edge Context [2025]

Result Video



Intermezzo

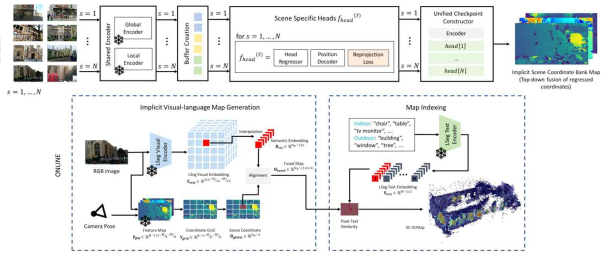
Other work

While **scene coordinate regression** is commonly used for **localization** only, we explore its potential for **semantic mapping**.

SC-VLMaps (ICRA 2026, Vienna)

Our proposed method

project page: https://nfprojets.github.io/scvlmaps-blog/



OUR FRAMEWORK:

Offline: build the scene coordinate bank → **Online:** generate the visual–language map.

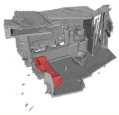
Reference: Nanda Febri Istighfarin, Baehoon Choi, and HyungGi Jo*, "SC-VLMaps: Depth-Free Visual-Language Mapping via Scene Coordinate Regression," International Conference on Robotics and Automation (ICRA 2026), Austria, 2026.

SC-VLMaps

Result: Indoor

Scene





Comparison to the baseline

7Scenes: Pumpkin

Generated Map

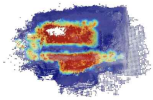


Ours (SC-VLMaps)

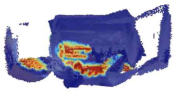


VLMaps

Where is the cabinet?



Ours (SC-VLMaps)



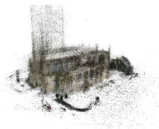
VLMaps

SC-VLMaps

Result: Outdoor

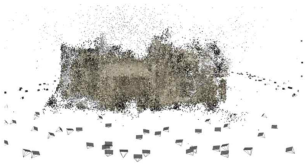
Scene



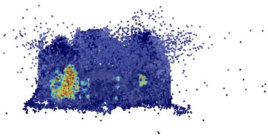


Cambridge Landmarks: St. Mary's Church

Unlike previous work, we succeed outdoors.



SC-VLMaps Generated Map



Where is the window?

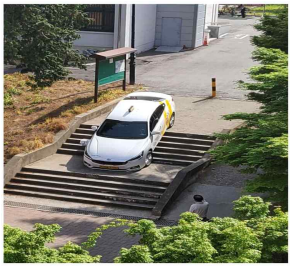
Semantic Visual SLAM

Motivation

- Missing information of Drivable Region for autonomous navigation
- Existing navigation system = GIS data + GPS Signal only



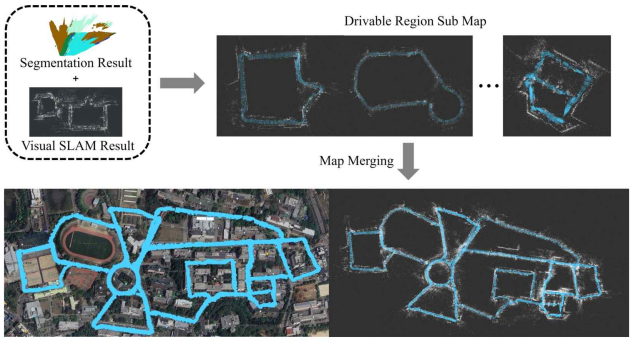
Google map



Accident case in JBNU

Semantic Visual SLAM

Large-scale RGBD SLAM



Reference: ChangWan Ha, DongHyun Yang, Gicheol Wang , Sung Chang Kim, and HyungGi Jo*, "Real-Time Drivable Region Mapping Using an RGB-D Sensor with Loop Closure Refinement and 3D Semantic Map Merging," Applied Sciences, vol. 14, no. 24, pp. 11613, Dec. 2024.

Semantic Visual SLAM

Large-scale RGBD SLAM

RGB-D Camera-Based Large-scale Drivable Region Mapping

전북대학교 JEONBUK NATIONAL UNIVERSITY

AI Robotics Lab JEONBUK NATIONAL UNIVERSITY

Reference: ChangWan Ha, DongHyun Yang, Gicheol Wang , Sung Chang Kim, and HyungGi Jo*, "Real-Time Drivable Region Mapping Using an RGB-D Sensor with Loop Closure Refinement and 3D Semantic Map Merging," Applied Sciences, vol. 14, no. 24, pp. 11613, Dec. 2024.

CES 2026

SnapSpace

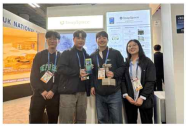
"Portable spatial information device with multi-sensor fusion-based **SLAM** technology"



CES 2026

SnapSpace

JBNU AIR Lab.
'2026 CES' Innovation Awards (Las Vegas)





[모듈형 구조 설계]



[실외 환경 매핑]



[공간 맵 생성 결과]

Large-scale Mapping

Large-scale Mapping & Localization

3D LiDAR SLAM

LIO/ LiDAR SLAM (Front-end)
1. LeGO-LOAM [1]
2. LIO-SAM [2]
3. Faster-LIO [3]
4. VoxelMap++ [4]
5. GLIM [5]
6. VoxelSLAM [6]
7. RESPLE [7]

Loop Detection (Back-end)
1. Scan Context [13]
2. BTC [14]

Global Registration (Back-end)
1. TEASER [11]
2. Quatro [12]

Local Registration
GICP [8]

Offline
- Bundle Adjustment HBA [9]
- Map Merging LAMM [10]

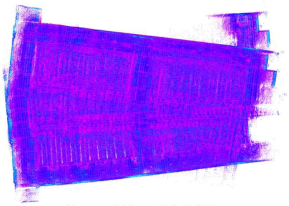
Problem
1. **Remaining drift error** remained after long-range operation, which degraded global map consistency
2. **High memory usage** increased with map growth, which reduced runtime efficiency
3. **More efficient mapping & localization** was required to support long-term and large-scale deployment

[1] SHAN, Tixiao; ENGLOT, Brendan. Lego-loam: Lightweight and ground-optimized lidar odometry and mapping on variable terrain. In: 2018 IEEE/RSJ international conference on intelligent robots and systems (IROS). IEEE, 2018. p. 4758-4765.
[2] SHAN, Tixiao, et al. Lio-sam: Tightly-coupled lidar inertial odometry via smoothing and mapping. In: 2020 IEEE/RSJ international conference on intelligent robots and systems (IROS). IEEE, 2020. p. 5135-5142.
[3] BAI, Chunge, et al. Faster-LIO: Lightweight tightly coupled LiDAR-inertial odometry using parallel sparse incremental voxels. IEEE Robotics and Automation Letters, 2022, 7.2: 4861-4868.
[4] WU, Chang, et al. Voxelmap++: Mergeable voxel mapping method for online lidar-inertial odometry. IEEE Robotics and Automation Letters, 2023, 9.1: 427-434.
[5] KOIDE, Kenji, et al. GLIM: 3D range-inertial localization and mapping with GPU-accelerated scan matching factors. Robotics and Autonomous Systems, 2024, 179: 104750.
[6] LIU, Zheng, et al. Voxel-slam: A complete, accurate, and versatile lidar-inertial slam system. arXiv preprint arXiv:2410.08935, 2024.
[7] CAO, Ziyu; TALBOT, William; LI, Kailai. RESPLE: Recursive spline estimation for LiDAR-based odometry. IEEE Robotics and Automation Letters, 2025.
[8] SEGAL, Aleksandr; HÄHNEL, Dirk; THRUN, Sebastian. Generalized-icp. In: Robotics: science and systems. 2009. p. 435.
[9] LIU, Xiyuan, et al. Large-scale LiDAR consistent mapping using hierarchical LiDAR bundle adjustment. IEEE Robotics and Automation Letters, 2023, 8.3: 1523-1530.
[10] WEI, Haoruo, et al. Large-Scale Multi-Session Point-Cloud Map Merging. IEEE Robotics and Automation Letters, 2024.
[11] YANG, Heng; SHI, Jingnan; CARLONE, Luca. Teaser: Fast and certifiable point cloud registration. IEEE Transactions on Robotics, 2020, 37.2: 314-333.
[12] LIM, Hyungtae, et al. Quatro++: Robust global registration exploiting ground segmentation for loop closing in LiDAR SLAM. The International Journal of Robotics Research, 2024, 43.5: 685-715.
[13] KIM, Giseop; KIM, Ayoung. Scan context: Egocentric spatial descriptor for place recognition within 3d point cloud map. In: 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2018. p. 4802-4809.
[14] YUAN, Chongjian, et al. Btc: A binary and triangle combined descriptor for 3-d place recognition. IEEE Transactions on Robotics, 2024, 40: 1580-1599.

Large-scale Mapping & Localization

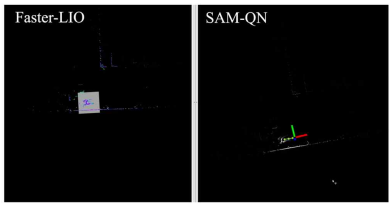
LiDAR Inertial Odometry + Loop closure

Approach
1. Local mapping and pose estimation via LIO
2. Loop-closure constraint generation using Scan Context and trajectory optimization via PGO



Faster-LIO + SC-PGO

Problem
1. Repetitive structures cause unreliable loop detection
2. Large drift limits the effectiveness of loop closure and PGO



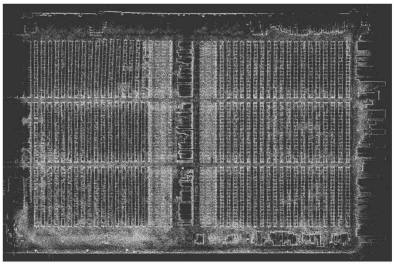
Faster-LIO +SAM-QN

Large-scale Mapping & Localization

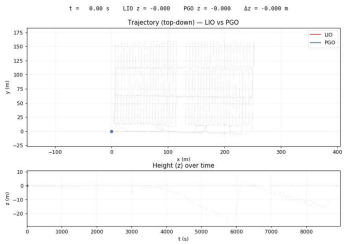
LiDAR Inertial Odometry + Submap management

Solution

1. LIO + PGO + Submap management



Mapping Result



Trajectory

Large-scale Mapping & Localization

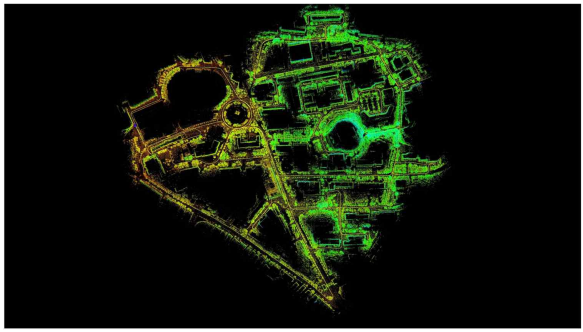
Warehouse Autonomous Navigation



Map-based Localization

Large-scale Mapping & Localization

JBNU Campus



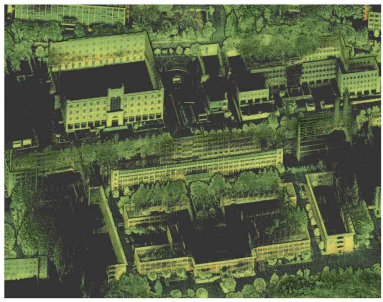
JBNU Campus Mapping

Large-scale Mapping & Localization

JBNU Campus



Map with Aerial Image

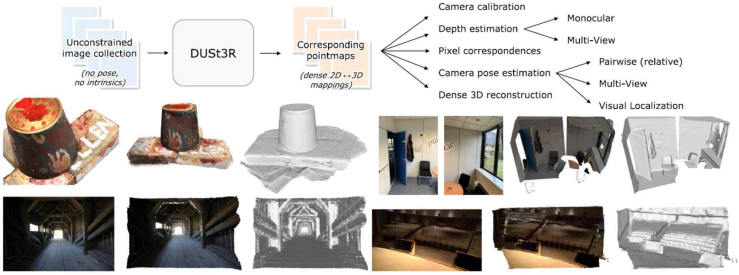


Details

Intelligent Robotic Systems

Foundation Model for Spatial AI

DUSt3R

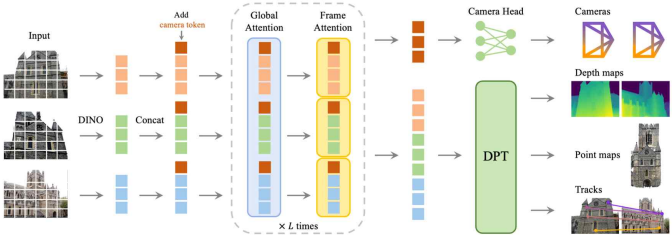


Reference: DUSt3R: Geometric 3D Vision Made Easy, CVPR 2024

Foundation Model for Spatial AI

VGGT

VGGT, a feed-forward neural network that directly infers **all key 3D attributes** of a scene, including camera parameters, point maps, depth maps, and 3D point tracks, from one, a few, or hundreds of its views



Reference: VGGT: Visual Geometry Grounded Transformer, CVPR 2025 Best Paper Award

Foundation Model for Spatial AI

VGGT

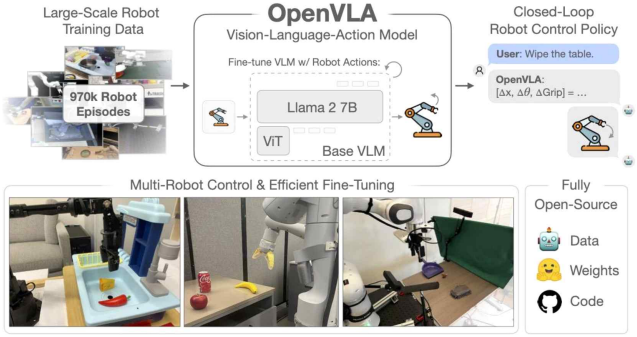
32 Views



Reference: VGGT: Visual Geometry Grounded Transformer, CVPR 2025 Best Paper Award

VLA Model

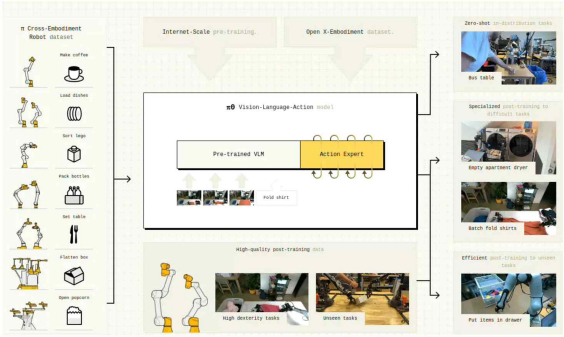
OpenVLA



Reference: OpenVLA: An Open-Source Vision-Language-Action Model

VLA Model

Physical Intelligence

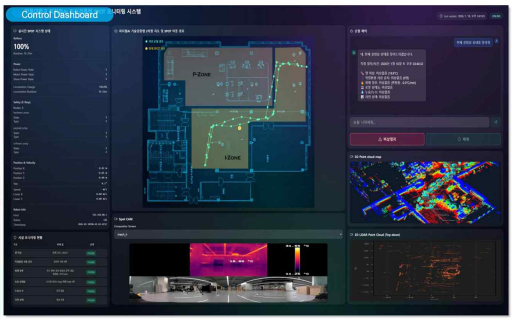


Reference: pi-0

Spatial AI for Multi-robot System

Global Space Control & Inspection







Humanoid

Humanoid Locomotion Technology



Reinforcement Learning for Humanoid Locomotion

- Developed a locomotion dynamics simulation environment by integrating the Unitree G1 model into the MuJoCo physics engine
- Trained the humanoid to stably track diverse velocity commands, including forward, lateral, and rotational motions

Humanoid Locomotion RL Results



Humanoid

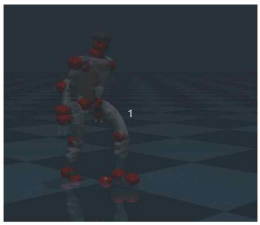
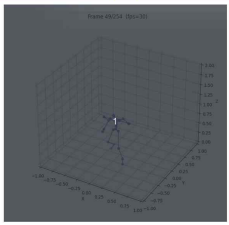
Humanoid Motion Retargeting

Humanoid Motion Generation Based on Human Motion Data Retargeting



- Human motion data and humanoid robots differ in joint configuration, link length, DoF, and joint-limit structure
- Motion retargeting is required to transform human motion data into feasible humanoid robot motions

Motion Retargeting Results


Reference: "Locomotion-Enhanced Whole-Body Imitation for Humanoid Teleoperation", CoRL 2026 Submitted

Humanoid-Manipulator

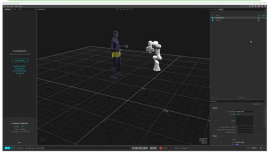
Heterogeneous Robot Collaborative Task

Manipulator – Humanoid Collaborative Task

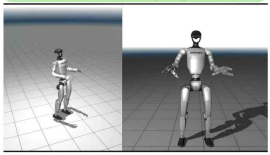


- Performed object arrangement and autonomous loading tasks into a target box using a manipulator
- Heterogeneous robot collaboration scenario : precise robotic-arm manipulation for block loading with whole-body humanoid teleoperation for box organization

Motion Capture View



Simulation and Retargeting Results



Real-Time Collaborative Task



Reference: "Locomotion-Enhanced Whole-Body Imitation for Humanoid Teleoperation", CoRL 2026 Submitted

AI Robotics Lab

Hand Pose Estimation

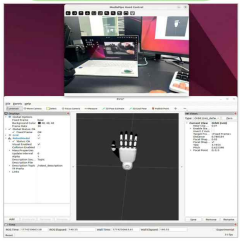
Vision-based Hand Pose Estimation



Real-Time Robot Hand Control based on Google Open-Source AI Library

- Vision-based hand motion estimation → Compute joint angles → Control robot hand in both simulation and physical world
- Estimate bending angles from the hand landmarks, then linearly map them to the six joints of the robot hand
- Validated individual control motions for the thumb, fist closing, and each finger

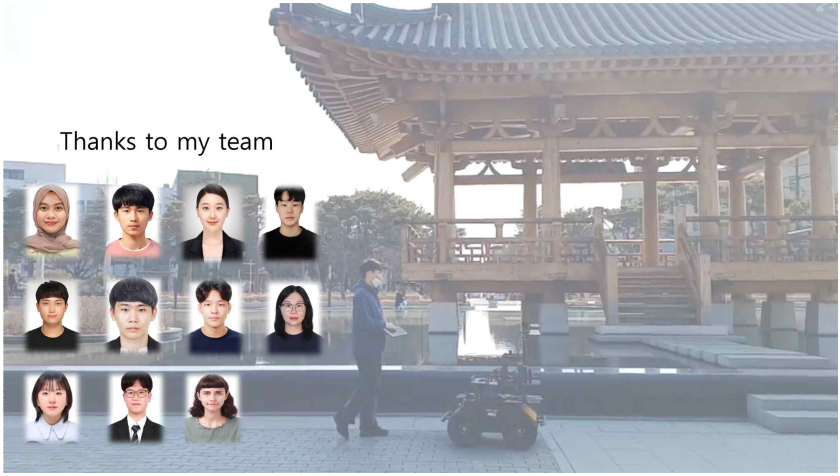
Robot Hand Pose Estimation



Robot Hand Control using Vision-based Hand Pose Estimation



Thanks to my team



Thank you.

Q&A

AI Robotics Lab

AI Robotics Lab



01. PARADIGM SHIFT

AI is moving into the Physical World.

FROM

Conversational AI

- Search
- Chat
- Recommendation
- Lives inside screens

→

TO · PHYSICAL AI

Embodied Intelligence

Sensing
Camera · Radar · Capacitive sensor

Planning
Path · Behavior · Intent

Control
Real-time · deterministic

Actuation
Steering · Braking · Haptics

"Future vehicles may become embodied AI systems on wheels."

02. 100-YEAR JOURNEY

100 Years of Steering Wheel Evolution



1900s
MECHANICAL
Pure mechanical control.
Wood, steel, human force.

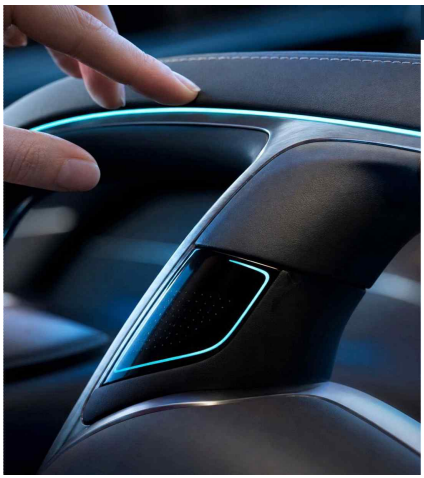
1960s
COMFORT
Power steering.
Driver fatigue drops. Mass mobility era.

1990s
SAFETY
Airbag integration.
The wheel protects, not just steers.

2000s
ELECTRONIC UX
Multifunction switches.
Phone, audio, cruise on the rim.

2020s
AI SENSING
HOD, capacitive sensing, biosensors.
The wheel becomes an interface.

"Steering wheel evolution reflects the evolution of automotive technology itself."



03. DESIGN PHILOSOPHY

From Mechanical Control to Human Experience (UX)

PAST	PRESENT	FUTURE
Steering only	UX-driven device Controls buttons, feedback, controls	AI interaction

FUTURE DESIGN KEYWORDS

Adaptive shape	Gesture interaction	Haptic communication	Biometric authentication
that changes with driving mode.	without touching a button	through your palms.	the car personalizes itself the moment you grip the rim

"Future steering wheels may understand drivers emotionally."

04. NEW INTERFACE

The Steering Wheel is becoming an AI Sensor Platform.

SENSING HOD Hands-on Detection	**SENSING** Capacitive Grip & gesture	**FEEDBACK** Haptic actuator Tactile alerts
VISION DMS Driver monitoring	**COMM** Light Bar Ambient signal	**BIO** Biosensing Heart · stress · fatigue

Hand → Wheel → Sensor → AI ECU → Vehicle Response

"Steering wheel is the closest AI interface to the human body — inside the vehicle."



05. USE CASES

Human-Centered AI Sensing



CASE 01

Driver Fatigue Detection

As drivers grow drowsy, signs appear on the wheel BEFORE the face.

Grip pressure change · Stress ↑ · Steering correction ↓

Wheel sensing → AI analysis → alert · ambient light · safety assist

Detect drowsiness before the driver does.

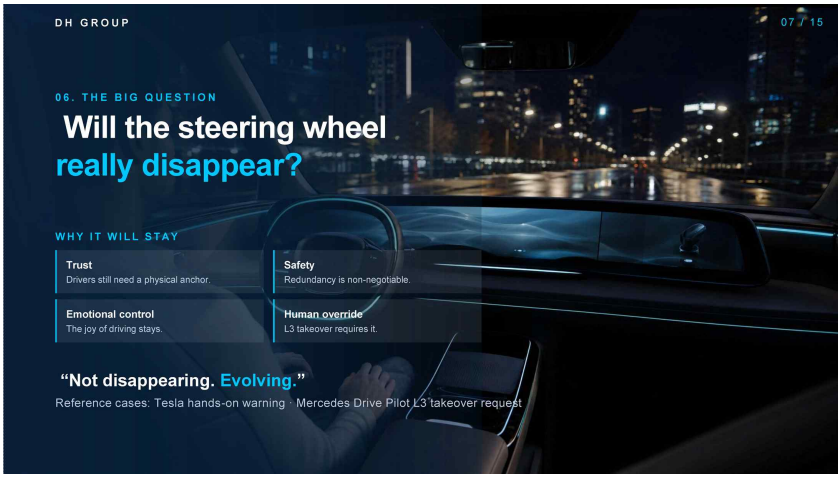
CASE 02

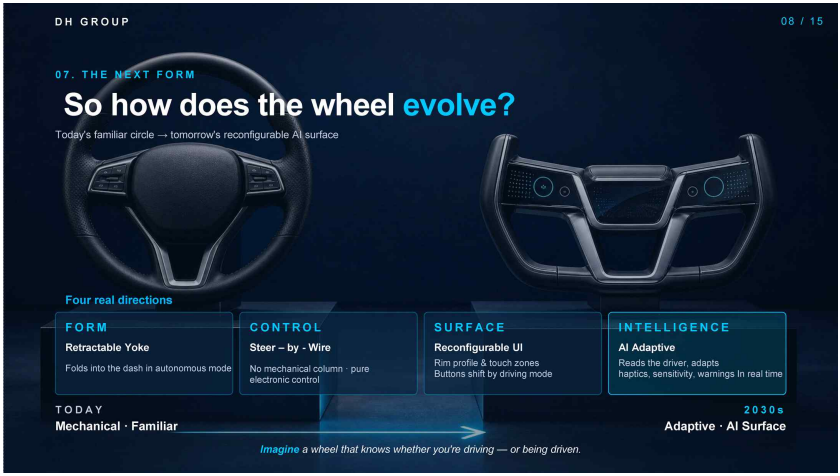
Emotional Interaction

When stress rises, the cabin **responds**:

- Adaptive heating in the rim
- Softer haptic pattern
- Calming voice & ambient color

*The car learns to **care**.*


DH GROUP
07 / 15
06. THE BIG QUESTION
Will the steering wheel
really disappear?
WHY IT WILL STAY
Trust
Drivers still need a physical anchor.
Safety
Redundancy is non-negotiable.
Emotional control
The joy of driving stays.
Human override
L3 takeover requires it.
"Not disappearing. Evolving."
Reference cases: Tesla hands-on warning · Mercedes Drive Pilot L3 takeover request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07. THE NEXT FORM
So how does the wheel evolve?
Today's familiar circle → tomorrow's reconfigurable AI surface
Four real directions
FORM
Retractable Yoke
Folds into the dash in autonomous mode
CONTROL
Steer – by - Wire
No mechanical column · pure electronic control
SURFACE
Reconfigurable UI
Rim profile & touch zones
Buttons shift by driving mode
INTELLIGENCE
AI Adaptive
Reads the driver, adapts haptics, sensitivity, warnings In real time
TODAY
Mechanical · Familiar
2030s
Adaptive · AI Surface
Imagine a wheel that knows whether you're driving — or being driven.

08. BEYOND THE PRODUCT

Physical AI is transforming the factory.

01
AI Vision Inspection
Catches leather wrinkle · scratch · anomaly

02
Robot Automation
Enables adaptive assembly cells

03
Digital Twin
Close simulation-to-line loop

04
Predictive Maintenance
Repairs equipment before it breaks

05
Smart Logistics
moves materials autonomously inside the plant.



FIELD EXAMPLE — AI VISION
Leather wrinkle · scratch · assembly anomaly detected in real time.

"Future factories will not only automate processes — they will make autonomous decisions."



09. THE HARDEST PART

AI Demo ≠ Mass Production.

ChatGPT can make mistakes. the user just tries again Cars can not.

REAL-WORLD CHALLENGES
What kills AI in production

ELECTRICAL EMC / EMI Tolerance	LIFETIME Durability 15 years
ENVIRONMENT Thermal / Humidity Variation	VARIANCE Sensor tolerance across hundreds of thousands of units

SAFETY FRAMEWORK
How we make it safe

FUNCTIONAL SAFETY ISO 26262	AI / SOTIF ISO 21448
CONTINUITY Fail-operational Design	ARCHITECTURE Redundancy

*Productization is where AI **earns the road.***

10. FROM DEMO TO ROAD · DH IN THE FIELD

DH Group in the Field.

Real production lines, real products, real engineering — what Physical AI looks like at DH every day.



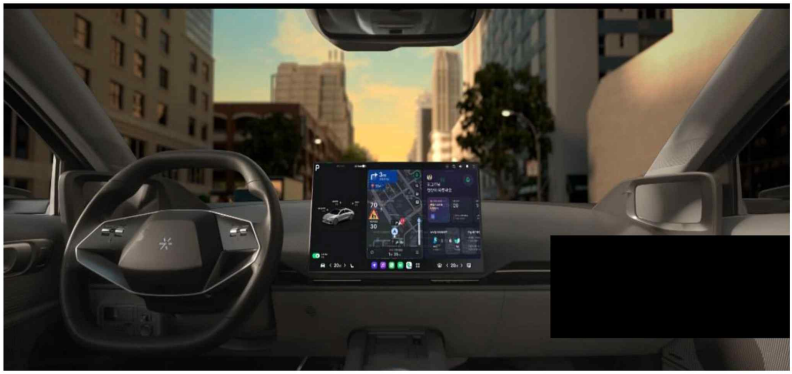






** Concept visuals — replaceable with DH's actual field photos in the same composition and tone.*

Next-Generation Steering Wheel Development for Hyundai's SDV Platform (42dot)



11. NEW ARCHITECTURE

Software Defined Vehicle changes everything.



Architecture change

PAST	**Hardware-centered vehicle**	each function had its own ECU, wire harness, little brain.
NOW	**Centralized Electrical / Electronic architecture**	fewer, more powerful compute domains
NEXT	**AI-defined mobility**	where behavior, features, even personality are defined by software, updated over the air.

"Future vehicles may evolve faster through software than hardware."

12. WHERE DH IS HEADING

From Components → to an Integrated System.

DH is building an **AI-based Driver Bio-Monitoring System (DBMS)** — a single integrated solution we will propose to global OEMs.



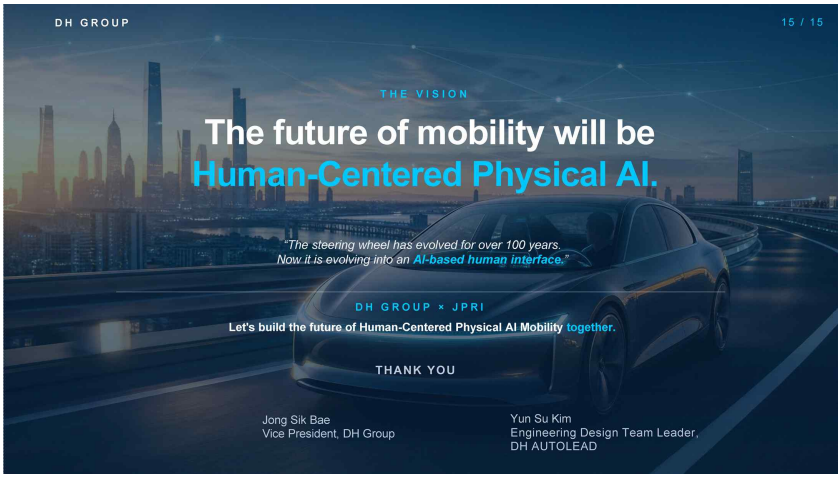
DBMS = INTEGRATED ARCHITECTURE
Steering Wheel Sensors → AI / NPU Controller → Center Display · HUD · Emergency Call

FIVE COMPONENTS · ONE SYSTEM

01	**ECG Sensing on the rim**	ECG · heart rhythm
02	**GSR Sensing through the skin**	Galvanic skin response · stress level
03	**Driver Monitoring Camera**	Gaze · posture · drowsiness
04	**NPU Controller**	AI signal fusion · reliability boost
05	**Display / HUD / eCall**	Result display · auto emergency call

DH'S NEXT strategic MOVE takes DRBM
Tech proposal to Global OEMs
Component supplier → System integrator

*"Not parts. Not features. **A complete in-cabin Physical AI platform.**"*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15 / 15
THE VISION
The future of mobility will be
Human-Centered Physical AI.
"The steering wheel has evolved for over 100 years.
Now it is evolving into an AI-based human interface."
DH GROUP × JPRI
Let's build the future of Human-Centered Physical AI Mobility together.
THANK YOU
Jong Sik Bae
Vice President, DH Group
Yun Su Kim
Engineering Design Team Leader,
DH AUTOLEAD

IMPULSE

Nondestructive Evaluation for Advanced Manufacturing

Luz D. Sotelo, Ph.D.
School of Mechanical Engineering
Contact: lsotelo@purdue.edu

JNBU-Purdue Research Institute Conference
June 12, 2026

PURDUE UNIVERSITY | School of Mechanical Engineering

Motivation

- **Advantages** of additive manufacturing: complexity, multi-materials, reduced assembly, readiness...
- **Testing, qualification, and validation** continue to be major barriers to adoption




NASA's Agency Wide Efforts to Improve Non-destructive Evaluation Methods for Additive Manufacturing and In-Space Inspection

Eric Burke
Senior Researcher NASA Langley NESB / OMSA NDE Program Manager

OMSA NDE Development Program Website

Contributors:

- Justin S. Jones, Ph.D., Materials Engineering Branch
  - Code 544 SME and Lead for Non-Destructive Evaluation (NDE)

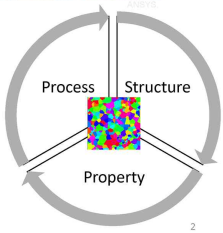
Proactive Workforce Development: ASNT's Vision for a Thriving NDT Industry

10 September 2021



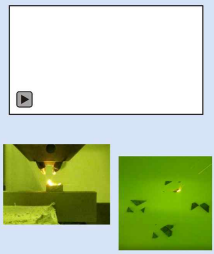
NATIONAL STRATEGY FOR ADVANCED MANUFACTURING

A Report by the
SUBCOMMITTEE ON ADVANCED MANUFACTURING
COMMITTEE ON TECHNOLOGY
of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

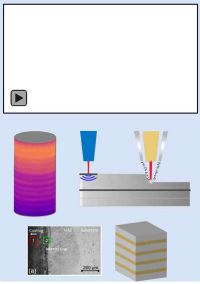


The Challenge

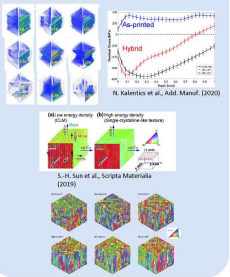
Additive Manufacturing



Hybrid Manufacturing

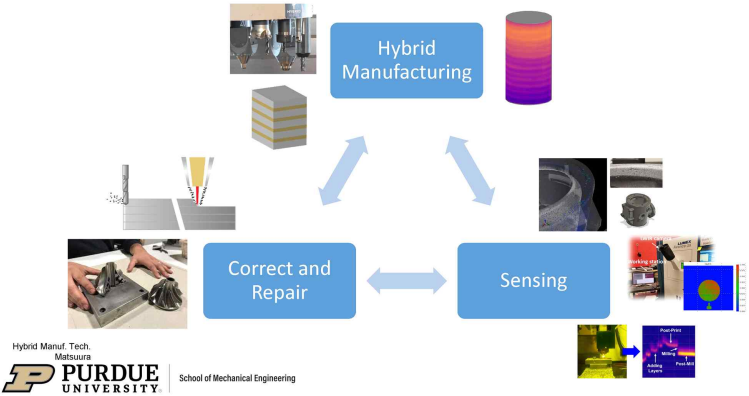


Heterogeneity



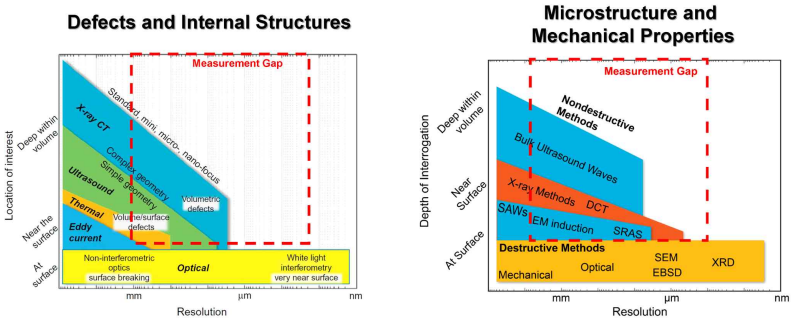
L. D. Sotelo et al., Ultrasonics 110, 106269 (2021).
M. P. Sealy et al., J. Manuf. Sci. Eng. 140, 6 (2018).
Z. Smoqi et al., Mat. & Des. **197**, 109229 (2021).

Goal: Enable adoption of AM and hybrid AM via NDE



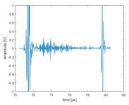
Hybrid Manuf. Tech.
Matsuura

NDE Gap

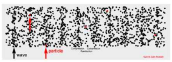


Modified from: L. W. Koester et al., *Additive Manufacturing for the Aerospace Industry* (Elsevier, 2019)

Approach: Wave-Material Interaction



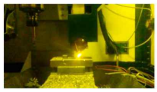
Waves
(NDE)



Process monitoring
Quantify mechanical properties
Detect defects
Understand material PSP relationships

Improved design and manufacturing of wave systems

New applications for acoustics and electromagnetics
Realize complex multi-material structures
Account for wave responses of novel materials



Materials
(Manufacturing)

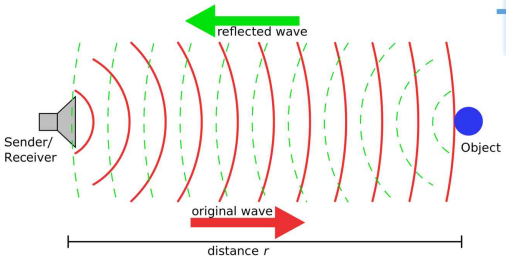


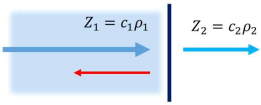
Im. Cr. A. Arrieta (Purdue University)

Ultrasonic NDE: Modeling and Experimental Tools

Ultrasonic Wave Propagation

- Ultrasonic waves travel through homogeneous media and scatter from **acoustically distinct** objects.





Images: Wikipedia: Ultrasound
Keyence.co.uk: metallographic-structure

Ultrasonic Wave Propagation

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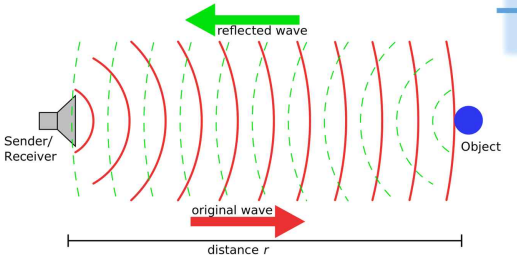

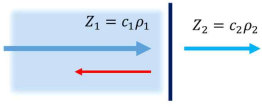

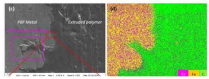

Y.H. Chue et al., Addit. Manuf., 2020

Images: Wikipedia: Ultrasound
Keyence.co.uk: metallographic structure

Ultrasonic Wave Propagation

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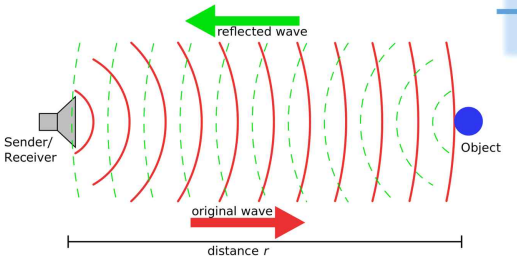
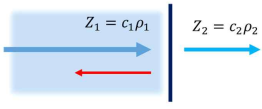
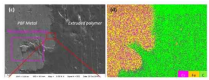
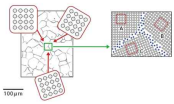






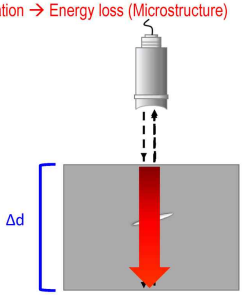
Y.H. Chue et al., Addit. Manuf., 2020

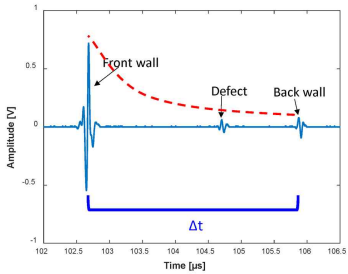


Images: Wikipedia: Ultrasound
Keyence.co.uk: metallographic structure

Ultrasonic NDE

- Defect detection
- Wave Speed → Energy storage (Elasticity)
- Attenuation → Energy loss (Microstructure)

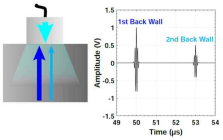




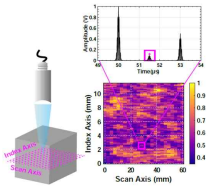
Ultrasonic Measurement Capabilities

Fundamental

Individual Signals A-scans (Bulk)

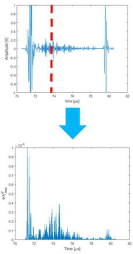


C-scans (Property Maps)

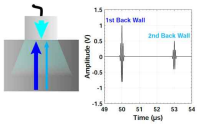


Advanced

Spatial Statistics (Bulk and Maps)



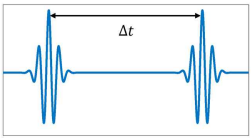
Individual Signals (A-scans)

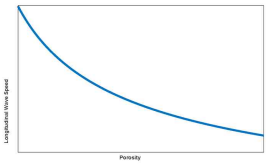


Wave Speed

- Mathematically, the **Christoffel equations** relate elastic wave speeds (phase velocities) to the elasticity tensor in anisotropic solids
- Wave speed can be directly correlated to microstructural features (porosity) through effective medium models, and stress through elastodynamic models.







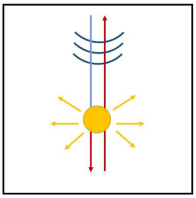
For an isotropic volume: $c_L = \sqrt{(K^* + 4G^*/3)/\rho}$

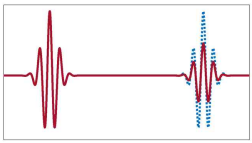
$c_L \propto \sigma^{-1}$

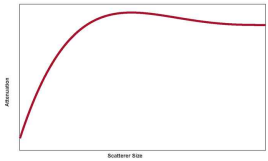
K^* - effective bulk modulus
G^* - effective shear modulus
ρ - density

Attenuation

- Ultrasonic attenuation can be directly correlated to microstructural features such as **grain size**



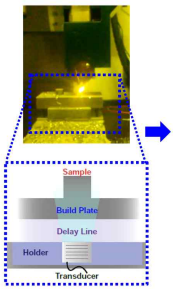


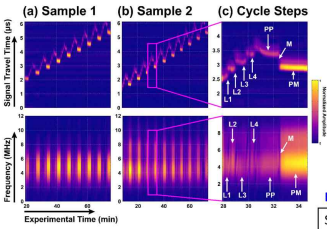


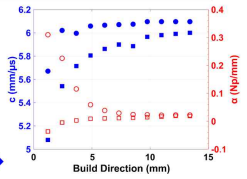
$\alpha_{Rayleigh} \propto L^3 f^4$
$\alpha_{Stochastic} \propto L f^2$
$\alpha_{Geometric} \propto 1/L$

L – Scatterer (grain) size
f - Frequency

Example: In situ monitoring for metal hybrid AM







Stiffness ↑ Grain Size ↑

Bulk Ultrasonic Properties

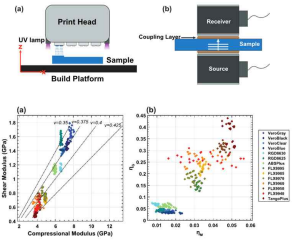
Sample	1 - ○	2 - □
Wave Speed (mm/μs)	6.1	6.0
Relative Attenuation (Np/mm)	0.022	0.019

Stiffness ↓ Grain Size ↓

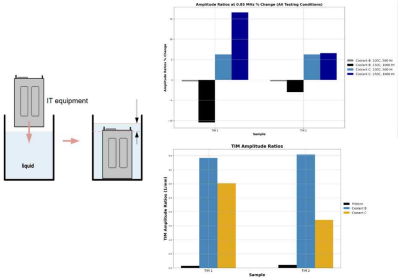
L.D.Sotelo et al., (JASA, 2021)

Examples: Bulk material characterization

Viscoelastic properties of 3D-printed photopolymers

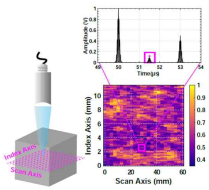


Monitoring fluid and TIM degradation for data centers

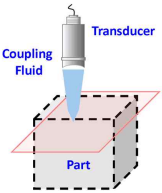


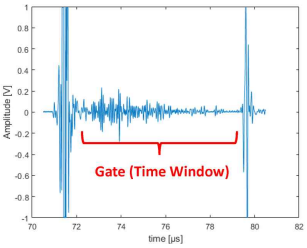
L. D. Sotelo, A. O. Vignola, C. A. Brown, K. Sampath, M. D. Guild, RNDE, 2023
J. Birkenmeyer, B.Chetri, S. Bansal, L.D. Sotelo, ITHERM, (2025)
Im.Cr: Alibaba

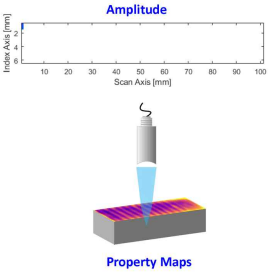
C-scans



Ultrasonic C-Scan Mapping







Geometry is known and surfaces are smooth*

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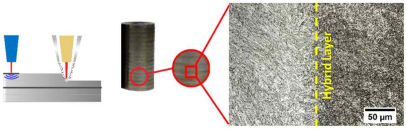
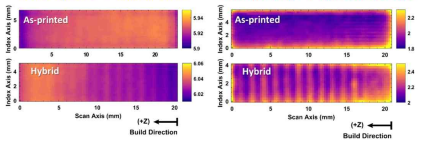
Examples: Local Property Maps

Residual stress and microstructure mapping for hybrid AM

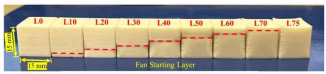


Wave Speed → Stress state

Attenuation → Microstructure

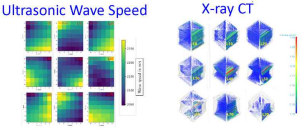


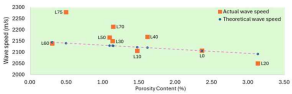
PSP for FFF: effect of cooling conditions



Ultrasonic Wave Speed

X-ray CT





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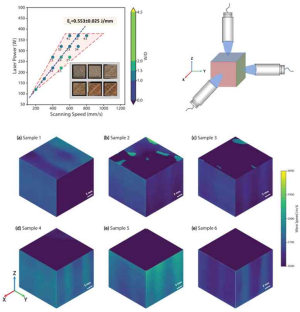
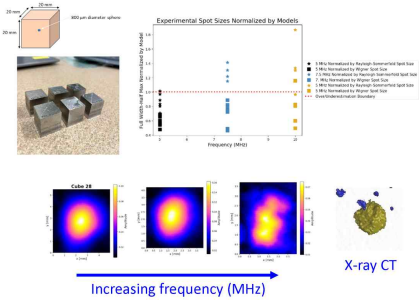
L.D.Sotelo et al., (Ultrasonics, 2020)
M.P. Sealy, R. Karunakaran, L.D. Sotelo, et al. (CIRP Annals, 2020)
P.Pandit, A. Keim, M. McClain, L.D. Sotelo (In Prep., 2026)

Examples: Local Property Maps

PSP relationships for metal AM



Multimodality to Characterize Internal Structures



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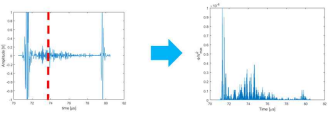
H. Adepu, J. Birkenmeyer, P. Pandit, L.D. Sotelo (In Prep., 2026)
J. Birkenmeyer, H. Adepu, L.D. Sotelo (In Prep., 2026)

Spatial Statistics



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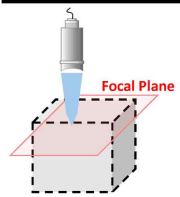
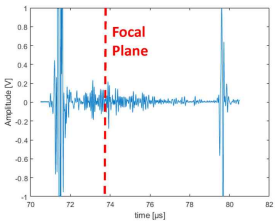
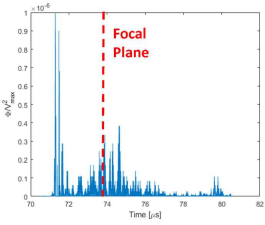
Ultrasonic Scattering – Spatial Statistics

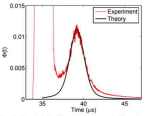






Variance

$$\Phi_{exp}(t) = \frac{1}{N-1}\sum_{i=1}^{N}\left|\phi_i(t) - \bar{\phi}(t)\right|^2$$



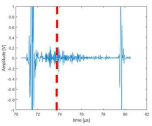
Does not require geometry knowledge

G. Ghoshal and J. A. Turner. J. Acoust. Soc. Am. (2010)

Ultrasonic Scattering Models

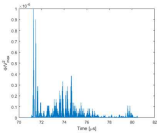
- Scattering Response

$$\phi(t) = \iint \underbrace{R(t) \otimes A_\beta(\mathbf{x})}_{\text{Source}} \overbrace{G_{\beta\alpha}(\mathbf{x}, \mathbf{x}', t)}^{\text{Green's Function}} \underbrace{B_\alpha(\mathbf{x}') \otimes S(t)}_{\text{Receiver}} d\mathbf{x} d\mathbf{x}'$$



- Diffuse field measurements

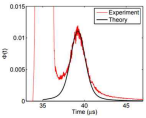
$$\langle \phi(t)^2 \rangle - \langle \phi(t) \rangle = \langle \phi(t)^2 \rangle = \Phi(t)$$



- Number of Scattering Events
- Material Properties
- Experimental Setup

Ultrasonic Scattering Models

- Normal Incidence Single Scattering



Diffuse Backscatter Coefficient — Transducer Energy Distribution

$$\Phi_{SSR}(t) = A_{exp}\left[\frac{\pi}{2}\frac{\omega_o^4}{c_L^8}\tilde{\eta}(L)\Xi^{\cdots\hat{p}\hat{p}\hat{q}\hat{q}}_{\cdots\hat{p}\hat{p}\hat{q}\hat{q}}(\boldsymbol{\pi},\boldsymbol{\nu},\boldsymbol{\rho}_L)\right] \times \exp\left[\frac{-t^2}{\sigma^2}\right]\int_0^\infty \frac{w_o^2}{w_1(z)w_2(z)} \times \exp\left[-4\alpha_L(\omega_o,L)z - \frac{4z(z-tc_L)}{\sigma^2 c_L^2}\right]dz$$

Calibration

G. Ghoshal and J. A. Turner. J. Acoust. Soc. Am. (2010)

$\eta(L)$:
- Grain size
- Grain size distribution
- Morphology/Elongation

$\Xi^{\cdots\hat{p}\hat{p}\hat{q}\hat{q}}_{\cdots\hat{p}\hat{p}\hat{q}\hat{q}}$:
- Orientation
- Elastic properties
- Stress



Assumptions:
- Grain morphology
- Statistical homogeneity
- Single scattering regime

Ultrasonic Scattering Models

- Double Scattering

$$\Phi_{SSR}(t) = A_{exp}\,\Gamma_{\mathrm{SSR}}\,\psi$$

$$\Phi_{DSR}(t) = \Phi_{SSR}(t) + \Phi_{LLL}(t) + \Phi_{LTL}(t)$$

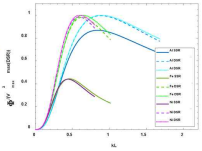
Calibration — Transducer

$$\Phi_{LLL(t)} = A_{exp}\Gamma_{\mathrm{LLL}}\,\psi_{LLL} \qquad \Phi_{LTL(t)} = A_{exp}\,\Gamma_{LTL}\,\psi_{LTL}$$

DBC

$$\Phi_{LTL(t)} \gg \Phi_{LLL(t)}$$

P. Hu and J. A. Turner, J. Acoust. Soc. Am. (2017)



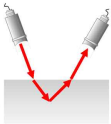
N.Matz, L.D.Sotelo, J.A. Turner, (JASA, 2025)



- Generalized Model

Calibration — DBC — Transducer

$$\Phi_G(t) = A_{exp}\,\Gamma_{XX'} \times \exp\left[\frac{-t^2}{\sigma^2}\right]\int_0^\infty dxdydz \frac{1}{w_1(Z_R)w_2(Z_R)w_1(Z_S)w_2(Z_S)} \times \exp\left[-\frac{2X_R^2}{w_1^2(Z_R)} - \frac{2X_S^2}{w_1^2(Z_S)}\right]$$



$$\times \exp\left[-\frac{2Y_R^2}{w_2^2(Z_R)} - \frac{2Y_S^2}{w_2^2(Z_S)} - \frac{2Z_R^2}{\sigma^2 c_{\chi'}^2} - \frac{2Z_S^2}{\sigma^2 c_\chi^2} + \frac{1}{\sigma^2}\left(\frac{Z_S}{c_\chi} - \frac{Z_R}{c_{\chi'}}\right)^2\right] \times \exp\left[\frac{2}{\sigma^2}\left(\frac{Z_S}{c_\chi} - \frac{Z_R}{c_{\chi'}}\right)t - \left(\frac{t}{\sigma}\right)^2 - 2\alpha_{\chi'}Z_R - 2\alpha_\chi Z_S\right]$$

A.P.Arguelles and J. A. Turner, J. Acoust. Soc. Am. (2019)

Statistical Thresholds

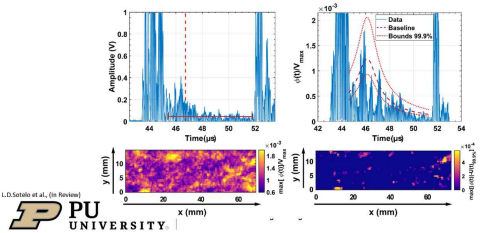
- Statistical Bounds

Y. Song et al., Ultrasonics (2017)

$$E[\phi_{max}(t)] \approx E[\phi(t)] = [\sqrt{1lnN} - (ln(lnN) + ln\pi - 2\gamma)/2\sqrt{2lnN}]\phi^*(t)$$ Expected Value

$$U(t) = [\sqrt{2lnN} - (lnlnN + ln\pi + 2\ln[-\ln(1-(1-\alpha)/2)])/2\sqrt{2lnN}]\,\phi^*(t)$$ Upper Bound

$$L(t) = [\sqrt{2lnN} - (lnlnN + ln\pi + 2\ln[-\ln((1-\alpha)/2)])/2\sqrt{2lnN}]\,\phi^*(t)$$ Lower Bound



L.D.Sotelo et al., (In Review)

$$\phi^*_{theory} = \sqrt{\Phi_{SSR}(t)} \qquad \phi^*_{exp} = \sqrt{\Phi_{exp}(t)}$$

Assumptions:
- ~~Grain morphology~~
- ~~Statistical homogeneity~~
- ~~Single-scattering regime~~
- Normally distributed in time

Grain sizing
$L_{UT} = 56\ \mu m$

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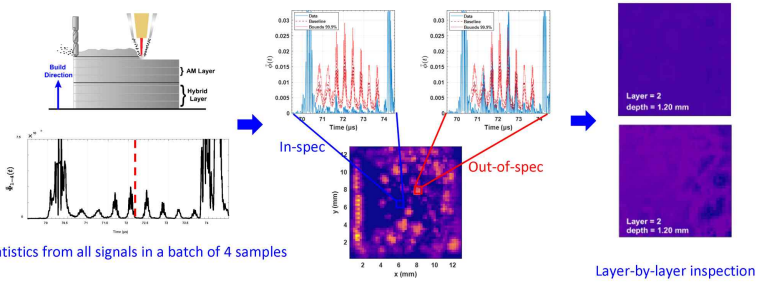
Example: In-spec vs out-of-spec microstructure in hybrid AM



Statistics from all signals in a batch of 4 samples

Layer-by-layer inspection

L.D. Sotelo et al., (In Prep.)
R. Karunakaran, L.D. Sotelo et al., Addit. Manuf. (2023)

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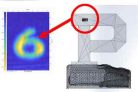
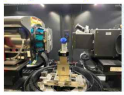
Workforce Development: NDE for AM

- Undergraduate Hands-on Curriculum:
  - Additive Manufacturing: FFF, SLS, LPBF
  - Nondestructive Evaluation: X-ray CT, Ultrasound, Optical
  - 8 articles (1 published, 7 in prep.), 8 students in graduate school, 3 students in AM industry/gov roles
  - **Looking for FALL 2026 projects/speakers**



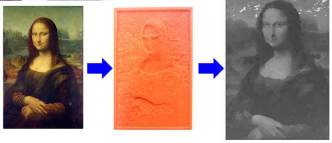












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THANK YOU!

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- Collaborators: Joseph A. Turner, Michael P. Sealy, Shubrha Bansal, Rakeshkumar Karunakaran, Cody S. Pratt, Amelia Vignola-Ware, Celeste Brown, David Schipf, Alec Ikei, Matthew D. Guild, Caleb Sieck, Amber Groopman, John Roth, Brad Kinsey, Jinjin Ha, Trevor Fleck, Paul Allison



NASA Nebraska Space Grant | College of Engineering, Nano-Engineering Research Core Facility | Office of Naval Research, Science & Technology | NSF | The National Academies of Sciences Engineering Medicine | U.S. Naval Research Laboratory | Cooling Technologies Research Center | AmstedRail | United States Space Force | DOW

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About Purdue

Luz D. Sotelo
Contact: lsotelo@purdue.edu

PURDUE UNIVERSITY | School of Mechanical Engineering

Purdue Facilities – AM and Hybrid AM

- 20,000 sq. ft. research space at Purdue Research Park

Laser Powder Bed Fusion



Matsuura Lumex Avance 25 (X 2)
- 3D metal structures with a layer thickness of 50 µm and build speed of up to 35 cc/hr
- Hybrid system: additive and subtractive Build volume 10' x 10' x 28' approx.
- Reactive(magnesium, titanium, aluminum), refractory, and nonreactive (steel, nickel, bronze) materials respectively



Renishaw AM 400 (X 3)
- 3D metal structures with a layer thickness of 50 µm and build speed of up to 20 cc/hr
- Build volume 10' x 10' x 12' approx.
- Rapid prototyping and fabrication
- Available for UG courses and training

Directed Energy Deposition



Formalloy L2
- 3D metal structures from powder and wire form factors at deposition rate of up to 7 kg/hr
- 5 axis control
- Heated substrate to 500°C
- Enables repair, alloy development and multimaterial printing

Fused Filament Fabrication (For Metal AM)



Markforged Metal X (X 2)
- 3D metal and composite structures from fiber- and particle-loaded filament
- Layer thickness of 125 µm
- Materials include inconel, stainless steel, copper, carbon fiber
- Post-process sintering for near full density
- Viable for deployment applications

PURDUE UNIVERSITY | School of Mechanical Engineering

Purdue Facilities – Nondestructive Evaluation

Optical Metrology



Peel 3
- Structured light optical 3D scanner
- 0.1- 3 m components
- Up to 0.1 mm accuracy
- Up to 0.250 mm resolution



Kevence VR-6000
- Optical surface profilometer
- Resolution 0.1 μm
- Field of view: up to 24 mm

X-ray Computed Tomography



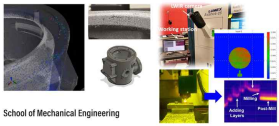
Phoenix V|tomel|x M300
- 300kV/500 W
- Dual microfocus and nanofocus tubes
- Maximum sample volume and weight: 103"x81"x62" and up to 50 kg

Ultrasonic Characterization



Tecscan TS3000
- Fully automated real-time scanning of samples
- Defect detection and material characterization
- 6-axis motorized
- Wide frequency range (0.5-50 MHz) for precision and bulk measurements

In Situ Monitoring and Feedback Control

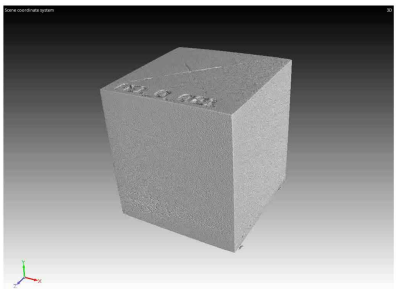


Sentient Science LWIR camera
- Identify anomalies in radiance and use hybrid for correction
- Component level demonstration

In situ ultrasound sensing
- Near real-time material characterization

Example: X-ray CT for Hybrid AM

- LPBF, 20 mm stainless steel cube with internal structures



Additional Slides

Recent Work

JASA Express Letters

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Volume 5, Issue 9
September 2025



SEPTEMBER 22 2025

A practical and frugal approach to building an ultrasonic immersion test setup

Harshith K. Adepu; Chelsea M. O'Donnell; Justin Y. Kim; Luz D. Sotelo

Check for updates

Author & Article Information

JASA Express Lett. 5, 092801 (2025)

https://doi.org/10.1121/10.0039221 Article history

Split-Screen Views PDF Share

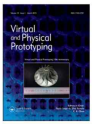
Ultrasonic inspection plays a critical role in nondestructive material characteri
Contact-based methods have been used in industry and field inspections for c

Recent Work



doi: 10.1109/ITherm55376.2025.11235803

Recent Work



Taylor & Francis
Virtual and Physical Prototyping
ISSN: 1745-2759 (Print) 1745-2767 (Online) Journal homepage: www.tandfonline.com/journals/nvpp20

Nondestructive evaluation of material properties in polymer additive manufacturing processes: moving towards process-agnostic qualification

Anna O. Keim, Partha P. Pandit, Luz D. Sotelo & Monique S. McClain

To cite this article: Anna O. Keim, Partha P. Pandit, Luz D. Sotelo & Monique S. McClain (2025) Nondestructive evaluation of material properties in polymer additive manufacturing processes: moving towards process-agnostic qualification, Virtual and Physical Prototyping, 20:1, e2569544, DOI: 10.1080/17452759.2025.2569544

To link to this article: https://doi.org/10.1080/17452759.2025.2569544

The 1st JBNU-Purdue Research Institute Conference

AI-Driven Warfare

Rapid Acquisition & the Future of Korea-U.S. Defense Cooperation

Toward a Third-Generation Defense Industrial Alliance

Prof. Won Joon JANG | Department of Advanced Defense Technology and Industry,
Jeonbuk National University



Contents

I. AI-Driven Battlefield Transformation
II. The Urgent Need to Reform Rapid Acquisition Systems
III. Toward a Korea-U.S. Defense Industrial Alliance
IV. JPRI as a Cooperation Platform
V. Conclusion

EXECUTIVE SUMMARY

Core Message

Battlefield is changing rapidly due to AI, Data, SW and Unmanned Systems

Traditional acquisition systems are too slow to respond to this new battlefield environment

Korea-U.S. Defense Cooperation must evolve toward **Joint Development, Co-Production, Join MRO and shared Supply Chains**

JPRI can serve as a practical platform to connect research, talent development, policy recommendation for defense industrial cooperation

Acquire Faster | Experiment Earlier | Produce At Scale | Sustain Together

I. | AI-DRIVEN BATTLEFIELD TRANSFORMATION

AI Is rewriting the Logic of Warfare

The battlefield is becoming a real-time data network with AI, data, SW, sensors, drones and autonomous systems

The decisive advantage is no longer platform performance alone, but the ability to sense, decide, act, and adapt faster

Future combat power will depend not only platform performance alone, but also on connectivity, adaptability, and speed

I. | AI-DRIVEN BATTLEFIELD TRANSFORMATION

From Platform-Centric to Network-Centric Warfare



Future combat power = platform capability × data connectivity × software adaptability

I. | AI-DRIVEN BATTLEFIELD TRANSFORMATION

Lessons from Recent Wars

Drones
commercial tech at tactical scale

EW
rapid counter-adaptation

AI
target recognition + data fusion

Software
continuous battlefield updates

Satellites
commercial satellite communications

Unmanned
Low-cost & Mass Production Capability

The Innovation Cycle of War is becoming much Shorter

Adaptation Speed is now becoming Combat Power

I. | AI-DRIVEN BATTLEFIELD TRANSFORMATION

War as a Speed Competition

Urgent Need	Fast Acquire	Flexible Test & Prototype	Mass Produce	Sustain & Rapid Upgrade
identify battlefield demand	contract and prototype	operational experimentation	industrial scale-up	MRO + supply chain

Fast Prototyping and continuous upgrading of fieldable systems are becoming a new winning strategy

The country that learns and adapts faster will gain strategic advantage

II. | THE URGENT NEED TO REFORM RAPID ACQUISITION SYSTEMS

Limits of Traditional Acquisition Systems

Traditional Acquisition Model

- designed for large and complex platforms
- fixed requirements & linear process
- long development cycle
- sequential testing
- late deployment

AI / Unmanned Reality

- fitted for AI, drones, robotics and software
- moving requirements
- short product cycles
- field data feedback
- continuous upgrades

A linear system cannot win a nonlinear technology race

II. | THE URGENT NEED TO REFORM RAPID ACQUISITION SYSTEMS

A New Rapid Acquisition Logic

Mission Problem	Open Solicitation	Prototype	Operational Test	Scale & Iterate
What must be solved?	Bring in innovators	Build fast	Learn in the field	Deploy + improve

Military cannot wait 15+ years to deploy technologies that may become outdated in just a months

Rapid Acquisition is no longer optional and its becoming mendatory

The goal is not 100% perfect requirements — it is faster learning and faster deployment with 85% fulfillments

II. | THE URGENT NEED TO REFORM RAPID ACQUISITION SYSTEMS

Three Global Models Show the Direction

United States	Israel	Ukraine
DIU, CSO, OTA, Replicator, DAWG	iHLS, civil-military startup ecosystem	Brave1 + wartime iteration
commercial tech at speed	tight innovation loop	battlefield-driven scaling

Common denominator:
flexible rules, rapid contracts, mission focus, and transition to deployment

II. | THE URGENT NEED TO REFORM RAPID ACQUISITION SYSTEMS

Korea's Current Challenge

70.2%
rated current rapid acquisition insufficient

2.26 / 5
average score for current system

94.4%
said reform is necessary

Source : JBNU Defense Industry Institute, Expert Survey Results, 2025

Korea's defense and manufacturing base is world-class

Rapid Pilot Project and Rapid Requirement systems exist in Korea, but they still face limitations

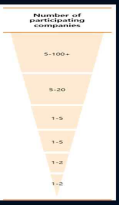
The bottleneck is institutional transition from prototype to fielded capability

II. | THE URGENT NEED TO REFORM RAPID ACQUISITION SYSTEMS

A Korean-Style Rapid Acquisition Model

Phase I Needs Identification & Problem Definition — mission demand → **Phase 2** Selection & Contracting — flexible contract → **Phase 3** Prototyping — operational experiment → **Phase 4** Deployment & Scaling — initial fielding, Iteration and Scale Up

Phase	Sub-Stage	Key Activities	Responsible Entity	Timeline
Phase 1 Needs Identification & Problem Definition	1-1 Needs Identification	Identification and submission of urgent operational needs from military units	Military units, K-DIU	Within 30 days
	1-2 Problem Definition	Refinement of military needs into problem statements aligned with advanced technologies	K-DIU PM, military, technical team	
	1-3 Market Research & Feasibility	Market analysis, TRL assessment, feasibility and risk analysis	K-DIU PM, technical team, external experts	
	1-4 Solicitation	Development and announcement of solution solicitation (Request for Proposal)	K-DIU PM	
Phase 2 Company Selection & Contracting	2-1 Proposal Submission	Submission of short proposals (≤ pages or ≤ slides)	Participating firms	Within 60–90 days
	2-2 Evaluation & Pitch	Technical evaluation and presentation (multi-stage review)	K-DIU PM, technical team, military users, experts	
	2-3 Final Selection & Contract	Final selection and contract/agreement signing	K-DIU PM, contracting authority	
Phase 3 Prototype Development & Experimentation	3-1 Prototype Development	PoC support, test unit matching, Live Demo Day, investor linkage	Selected firms, military test units, advisors, investors	Within 1–2 years
	3-2 Field Experimentation	Operational testing and validation in military environments	Military users, K-DIU	
Phase 4 Deployment, Iteration & Scaling	4-1 Initial Deployment	Initial procurement and deployment at requesting military unit	Military units	Within 2–5 years
	4-2 Rapid Iteration	Performance improvement based on user feedback and operational use	Military, K-DIU, developers	
	4-3 Scaling & Expansion	Transition to full-scale production (PPBEES), expansion to public sector, private partnerships, investment, and export	DAPA, military, K-DIU, industry, investors	



Source : Jang et al. 2026 Acquisition Research Program Symposium, Naval Postgraduate School, 2026.5.

60–90 days to contract | 1–2 years to prototype | 2–5 years to initial deployment

III | TOWARD A KOREA-U.S. DEFENSE INDUSTRIAL ALLIENCE

Evolution of Korea-U.S. Defense Cooperation

1st Generation
arms purchases + military assistance

→

2nd Generation
licensed production + technology transfer

→

3rd Generation
joint development + co-production + MRO + supply chains

In the age of AI, global rearmament, and supply chain instability, Korea and the U.S. need to develop its defense industry cooperation

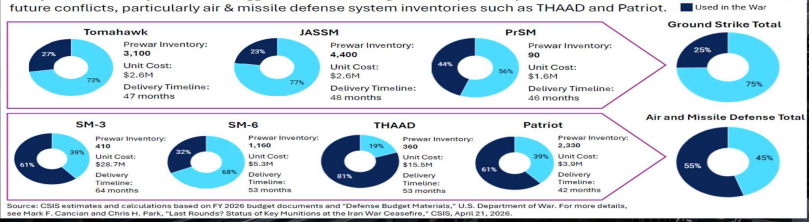
The next alliance agenda is production, sustainment, and innovation together

III | TOWARD A KOREA-U.S. DEFENSE INDUSTRIAL ALLIENCE

The U.S. Challenge: Lack of War Sustainment Capacity

Conflict w/Iran has consumed high levels of key U.S. munitions, placing additional pressure on missile production capacity

Analysis of seven key munitions suggests that remaining US stockpiles may be insufficient for future conflicts, particularly air & missile defense system inventories such as THAAD and Patriot.



Source: CSIS estimates and calculations based on FY 2026 budget documents and "Defense Budget Materials," U.S. Department of War. For more details, see Mark F. Cancian and Chris H. Park, "Last Rounds? Status of Key Munitions at the Iran War Ceasefire," CSIS, April 21, 2026.

Recent wars expose bottlenecks in munitions, missile inventories, shipbuilding, maintenance, and industrial surge capacity

III | TOWARD A KOREA-U.S. DEFENSE INDUSTRIAL ALLIENCE

Korea's Strategic Value



Korea has world-class manufacturing capabilities

Korea can support convert alliance technology into deployable industrial capacity

III | TOWARD A KOREA-U.S. DEFENSE INDUSTRIAL ALLIENCE

Four Pillars of Cooperation

Missile Co-Production	AIM-120, PAC-3, SM-series, JASSM, Tomahawk supply chains
Ammunition Hub	155mm production, joint stockpiling, Indo-Pacific resilience, RSF, PIPIR
Naval MRO & Shipbuilding	forward maintenance, repair backlogs, long-term joint sustainment
AI / Drones / Unmanned Systems	low-cost mass production, autonomy, counter-drone, software

The cooperation package must connect acquisition, production, maintenance, and export pathways

III | TOWARD A KOREA-U.S. DEFENSE INDUSTRIAL ALLIENCE

Institutional Enablers

RDP-A Jones Act	CMMC	RSF	PIPIR	Joint Council
lower procurement barriers	secure supply-chain entry	regional sustainment	Indo-Pacific industrial resilience	defense industry + acquisition + MRO

Without institutional pathways, strategic intent will not become industrial output

IV | JPRI AS A COOPERATION PLATFORM

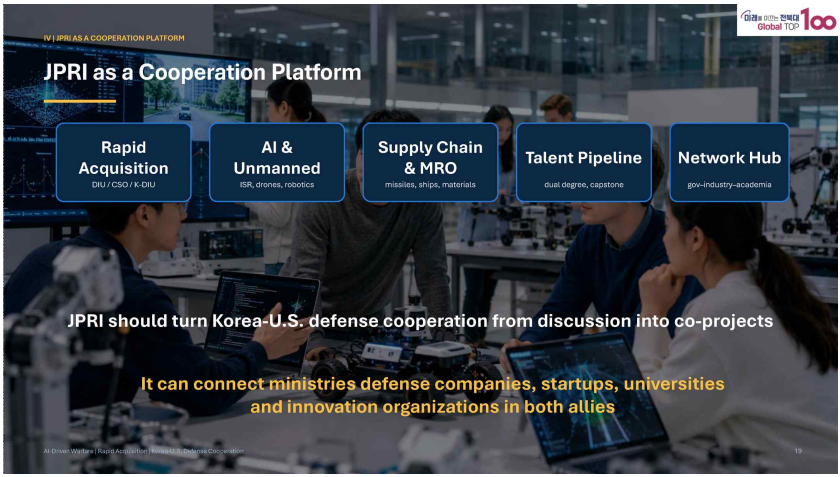
Why JPRI Matters

- Government and industry alone cannot fully address these challenges
- Universities must also play a central role
- Universities can support advanced technology research, talent development, policy analysis, international joint research, and testbed-based experimentation
- Jeonbuk National University and Purdue University are well positioned to contribute
- JPRI can become a practical platform connecting Korea–U.S. defense innovation, acquisition reform, and industrial cooperation
- It can move cooperation from discussion to real projects

From Discussion to Real Projects



Knowledge Hub | Talent Hub | Policy Hub | Technology Hub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JPRI as a Cooperation Platform
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DIU / CSO / K-DIU
AI & Unmanned
ISR, drones, robotics
Supply Chain & MRO
missiles, ships, materials
Talent Pipeline
dual degree, capstone
Network Hub
gov–industry–academia
JPRI should turn Korea-U.S. defense cooperation from discussion into co-projects
It can connect ministries defense companies, startups, universities and innovation organizations in both allies
AI-Driven Warfare | Rapid Acquisition | Korea-U.S. Defense Cooperation
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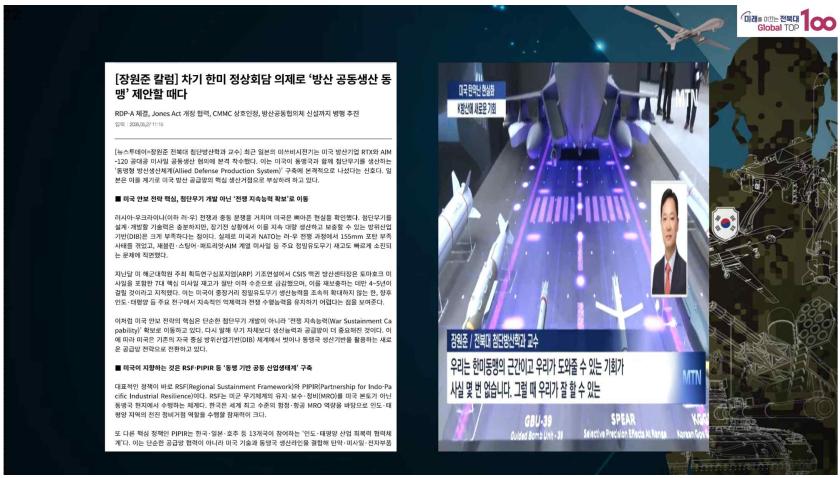
The 1st JBNU-Purdue Research Institute Conference
Q & A


[장원준 칼럼] 차기 한미 정상회담 의제로 '방산 공동생산 동맹' 제안할 때다
RDP-A 제정, Jones Act 개정 합력, CMMC 상호인정, 방산공동협의체 신설까지 병행 추진
입력 : 2026.01.27 11:19
■ 미국 안보 전략 핵심, 첨단무기 개발 아닌 '전쟁 지속능력 확보'로 이동
■ 미국이 지향하는 것은 RSF·PIPIR 등 '동맹 기반 공동 산업생태계' 구축
대표적인 정책이 바로 RSF(Regional Sustainment Framework)와 PIPIR(Partnership for Indo-Pacific Industrial Resilience)이다. RSF는 미군 무기체계의 유지·보수·정비(MRO)를 미국 본토가 아닌 동맹국 현지에서 수행하는 체제다. 한국은 세계 최고 수준의 함정·항공 MRO 역량을 바탕으로 인도-태평양 지역의 준거 정비거점 역할을 수행할 잠재력이 크다.
또 다른 핵심 정책인 PIPIR는 한국·일본·호주 등 13개국이 참여하는 '인도-태평양 산업 회복력 협력체'다. 이는 단순한 공급망 협력이 아니라 미국 기술과 동맹국 생산라인을 결합해 단박·미사일·군자부품
미국 탄도탄 현실화
K방산에 새로운 기회
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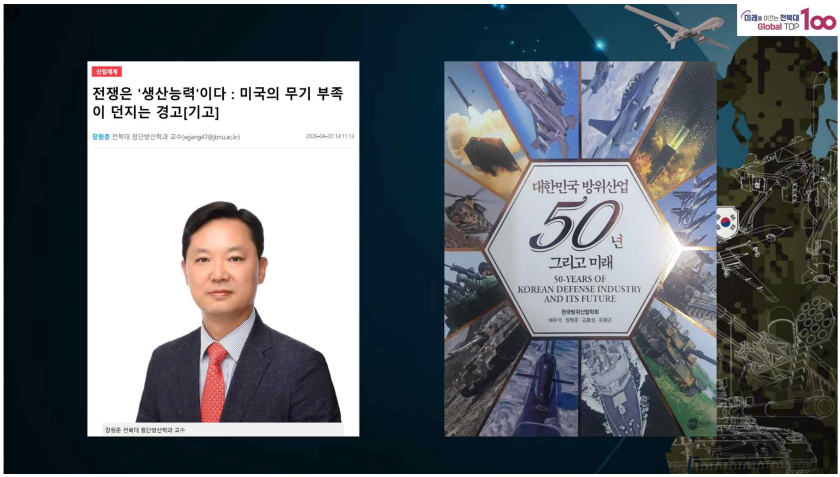
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산업세계
전쟁은 '생산능력'이다 : 미국의 무기 부족이 던지는 경고[기고]
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50년
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50-YEARS OF
KOREAN DEFENSE INDUSTRY
AND ITS FUTURE
한국방위산업학회

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Driving Korea's Balanced National Development

JEONBUK NATIONAL UNIVERSITY and PURDUE UNIVERSITY



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대학정보공시지표 12개 중

거점대 3위 이상 8개
종합점수 1위



라이덴랭킹 평가
거점 국립대 1위
최근 4년간 국제논문 중 상위 10% 인용 논문 비율

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실질적인 국가균형성장

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