Open Invited Track
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Safe, Fault Resilient and Health-Aware Control Design and Learning

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Abstract: Industrial and mission-critical systems increasingly operate in closed-loop settings where safety, resilience, and adaptability are indispensable. Control frameworks must ensure not only stability and performance under nominal conditions, but also reliability under abrupt faults, progressive degradation, and model uncertainty. Research in Fault-Tolerant Control (FTC) and Prognostics and Health Management (PHM) highlights the importance of integrated approaches that embed health information directly into the control design and learning processes. Over the past decade, Health-Aware Control (HAC) has emerged as a promising paradigm, where predictions of system state of health, remaining useful life (RUL), or reliability are explicitly incorporated into feedback loops to prolong asset lifespan and maintain performance levels. At the same time, data-driven methods and Reinforcement Learning (RL) open opportunities for designing optimal and adaptive controllers without requiring exact system models. Yet, ensuring safety during both exploration and exploitation phases in learning remains an unresolved challenge. Safe RL extends traditional RL by embedding safety, stability, and robustness guarantees, enabling deployment in safety-critical applications. This invited session will gather leading researchers to present and discuss theoretical foundations, computational tools, and practical applications of safe, fault-resilient, and health-aware control design and learning.

Submission Code for Open Invited Track: 3583k

How to Submit Everyone is welcome to submit a paper to this Open Invited Track!
(1) **Send us an email** if you are interested: mayank-shekhar.jha@univ-lorraine.fr
(2) **Write your paper** in the IFAC conference template (LaTeX resources: See https://www.latex-project.org/get/here)
(3) Submit via PaperCept: https://ifac.papercept.net/conferences/scripts/start.plLink
(4) Select **"Open Invited Track paper"** during submission.
(5) **Enter this code (important!): 3583k** ← Copy this exactly.
(6) Your paper will undergo peer review as regular papers.

1. INTRODUCTION

The increasing complexity of industrial and mission-critical systems demands closed-loop control strategies that extend beyond nominal operation. While traditional methods have focused primarily on stability, robustness, and efficiency, modern control frameworks must additionally guarantee safe performance under uncertainties, unforeseen faults, and progressive degradation.

Safe control design has emerged as a key direction in this context, emphasizing the need for control laws that enforce safety constraints over the entire operational horizon. Tools such as Control Barrier Functions (CBFs), predictive safety filters, and set-based approaches allow the design of controllers that provide rigorous guarantees on safety while ensuring optimal or near-optimal performance. Such methods are increasingly being combined with learning-based frameworks to create scalable, data-driven safe controllers suitable for real-world deployment.

Complementing this, **fault-resilient control design and learning** focuses on enabling closed-loop systems to tolerate unexpected faults or abnormal operating conditions without compromising performance. Fault-resilient methods go beyond detection and diagnosis; they incorporate redundancy, adaptability, and reconfiguration directly into control policies. Reinforcement learning and adaptive control have shown promise in learning fault-resilient policies from interaction data, particularly for complex systems where explicit fault models are not available.

Another emerging research frontier is **health-aware control learning**, where prognostic information, such as state of health or remaining useful life, is incorporated into the controller design and reconfiguration process. Unlike traditional PHM, that operates in open-loop, HAC explicitly considers degradation dynamics within closed-loop operation. This leads to controllers that optimize not only short-term performance, but also long-term reliability and asset lifespan. Health-aware RL further extends this paradigm, using data-driven prediction of degradation to guide exploration, reduce unsafe behaviors, and adapt to evolving system conditions.

Together, these research directions define the scope of this invited session: to integrate safe control design, fault-resilient strategies, and health-aware learning into unified frameworks. The aim is to advance theoretical foundations, computational methodologies, and practical applications that ensure trustworthy autonomy in safety-critical systems such as autonomous vehicles, robotics, power networks, and industrial processes.

2. KEY THEMES OF THE SESSION

This invited session aims to present innovative theoretical contributions, computational methodologies, and practical implementations across a wide spectrum of modern complex dynamical systems. We particularly encourage submissions that address open theoretical challenges while demonstrating applicability in real-world safety-critical systems. The main themes include:

- **Neural-Network-Based Methods:** Data-driven control strategies for fault resilience; neural observers and adaptive estimators; safe neural control with guaranteed stability.
- **Adaptive and Robust Control:** Adaptive fault-tolerant control strategies; resilient controllers under uncertain or time-varying health conditions.
- **Model Predictive Control (MPC):** Fault-resilient and health-aware MPC; robust and stochastic MPC under degradation; learning-based MPC frameworks.
- **Observer-Based and Estimation Frameworks:** Advanced state estimation methods for resilient and health-aware controllers; integration of prognostics and system identification.
- **Safe Control Design and Learning:** Reinforcement learning with safety guarantees; safe exploration strategies; long-term safety and performance optimization in uncertain environments.
- **Health-Aware Control (HAC) and Learning:** Integration of RUL predictions and prognostics into learning-enabled controllers; reliability-based design; health-aware RL algorithms.
- **Multi-Agent and Distributed Systems:** Coordination under degradation and faults; scalable and decentralized health-aware control for interconnected and networked systems.

3. RELEVANCE TO IFAC 2026 AND TECHNICAL COMMITTEES

The proposed invited session aligns with IFAC's mission of advancing automatic control in complex, uncertain, and safety-critical environments. It addresses the growing need for resilient and health-aware controllers that operate reliably under faults and degradation while leveraging emerging data-driven and learning-based techniques.

The session is directly relevant to the following IFAC Technical Committees (TCs):

- **TC 6.4 Fault Detection, Supervision & Safety of Technical Processes** – advancing fault resilience and health-aware control integration.
- Recently established Working group TC 6.4 titled: ***Health Aware Control Design and Safe Learning for Safety Critical Systems***
- **TC 6.2 Sustainable Control of Energy and Power Systems** – methods for degradation-aware and reliability-focused operation of critical infrastructure.
- **TC 2.4 Optimal Control** and **TC 3.4 Hybrid Systems** – advancing optimal control and hybrid dynamics under safety and fault-resilience constraints.

By highlighting safe learning, fault resilience, and health awareness, this session will foster dialogue across control theory, machine learning, and reliability communities. Outcomes will include new theoretical methodologies, computational frameworks, and demonstrations of real-world applications, ultimately contributing to the advancement of trustworthy autonomy in complex dynamical systems.

4. WEBSITE

Check the website here: http://w3.cran.univ-lorraine.fr/mayank-shekhar.jha/?q=content/ifac-2026-world-congress-open-invited-track-safe-fault-resilient-and-health-aware-control

5. ORGANIZERS

Mayank Shekhar JHA (CRAN, Université de Lorraine, France) is an Associate Professor at École Polytechnique de l'Université de Lorraine (Polytech Nancy) and a researcher at CRAN, a joint research unit between the University of Lorraine and the French National Scientific Research Center (CNRS) since 2018. He obtained PhD in 2015 at Ecole Centrale de Lille in France and has previously held post-doctoral research position at the Institut National des Sciences Appliquées de Toulouse (INSA Toulouse) France and Research Associate position at Rolls Royce Technology Centre at the University of Sheffield, United Kingdom in 2017. Dr. Jha has has authored around 30 publications in prestigious international conferences and journals, leads a Work package (WP) in recently accepted project funded by National Agency for Research (ANR) in France titled "Self-Organizing, Smart and Safe heterogeneous Robots Fleet by collective emergence for a mission (SOS)", has been **Co-PI** of three and **PI of one** industrially funded scientific projects with French National Space Agency (CNES) as well as Co-PI of one project with Dassault Aviation in last 5 years. Dr. Jha is an external collaborator and visiting researcher at NASA Ames Research Centre. Dr. Jha serves on editorial board of Scientific Reports, Nature and Associate Editor of Aerospace Science and Technology, Elsevier. Dr. Jha's current research interests include Safe Reinforcement Learning, Deep Learning based prognostics and Adiabatic Quantum Computing.

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Chetan S. Kulkarni is a staff researcher at the Prognostics Center of Excellence and the Diagnostics and Prognostics Group in the Intelligent Systems Division at NASA Ames Research Center. His current research interests are in Systems Diagnostics, Prognostics and Health Management. Specifically focused in developing physics-based models, prognostics of electronic systems, energy systems and exploration ground systems as well as hybrid systems. He completed his MS ('09), Ph.D. ('13) from Vanderbilt University, TN where he was a Graduate Research Assistant with the Institute for Software Integrated Systems and Department of Electrical Engineering and Computer Science. He completed his BE ('02) from the University of Pune, India. Prior to joining Vanderbilt, he was a Research Fellow at the Department of Electrical Engineering, IIT-Bombay, where his research work focused on developing low-cost substation automation system monitoring and control devices and partial discharge of high voltage transformers. Earlier to that he was a member of the technical team of the Power Automation group at Honeywell, India where he was involved in turnkey power automation projects and product development in substation automation. He is KBR Technical Fellow and AIAA Associate Fellow. Associate Editor for IEEE, SAE, IJPHM Journals on topics related to Prognostics and Systems Health Management. He has been Technical Program Committee co-chair at PHME18, PHM20-22. And co-chairs the Professional Development and Education Outreach subcommittee in the AIAA Intelligent Systems Technical Committee.

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Olga Fink, EPFL has been assistant professor of Intelligent Maintenance and Operations Systems at EPFL since March 2022. Before joining EPFL faculty, Olga was assistant professor of intelligent maintenance systems at ETH Zurich from 2018 to 2022, being awarded the prestigious professorship grant of the Swiss National Science Foundation (SNSF). Between 2014 and 2018 she was heading the research group "Smart Maintenance" at the Zurich University of Applied Sciences (ZHAW). Olga received her Ph.D. degree from ETH Zurich with the thesis on "Failure and Degradation Prediction by Artificial Neural Networks: Applications to Railway Systems", and Diploma degree in industrial engineering from Hamburg University of Technology. She has gained valuable industrial experience as reliability engineer with Stadler Bussnang AG and as reliability and maintenance expert with Pöyry Switzerland Ltd. Olga is serving as an editorial board member of several prestigious journals, including Mechanical Systems and Signal Processing, Engineering Applications of Artificial Intelligence, IEEE Internet of Things Journal and Reliability Engineering and System Safety. In 2018, Olga was honored as one of the "Top 100 Women in Business, Switzerland". Additionally, in 2019, earned the distinction of being recognized as a young scientist of the World Economic Forum. In 2020, 2021 and 2024, she was honored as a young scientist of the World Laureate Forum. In 2023, she was distinguished as a fellow by the Prognostics and Health Management Society. Olga's research focuses on Physics-Informed Machine Learning Algorithms, with a focus on Physics-Informed Graph Neural Networks, Hybrid Operational Digital Twins, Transfer Learning, Self-Supervised Learning, Deep Reinforcement Learning for Resilience and Health-Aware Control and Multi-Agent Systems for Intelligent Maintenance and Operations of Infrastructure and Complex Assets.

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Mohammed Chadli (SM'09) received his MSc from the Engineering School INSA-Lyon (France, 1999) and diploma from "Ecole Normale Sup.", the Ph.D. thesis in Automatic Control from the Lorraine University(UL)-CRAN-CNRS (Nancy, 2002). He was Lecturer and Assistant Professor at the "Institut National Polytechnique

de Lorraine" (UL-Nancy, 2000-2004). Since 2004, he was Associate Professor at the UPJV and is currently a Full Professor at the University Paris-Saclay Evry, IBISC Lab., France. He was a visiting professorship at the TUO-Ostrava (Czech Rep.), UiA (Norway), SMU-Shanghai (2014-2017), NUAA-Nanjing (2018-2025), and the University of Naples Federico II (Italy, 2019), University of Science and Technology Beijing (USTB, 2025). Dr. Chadli's research interests include filtering and control problems (FDI, FTC) and applications to vehicle systems, intelligence systems, network systems, and cyber-physical systems. He is the author of books(12) and book chapters (Wiley, Springer, Hermes), numerous articles (300+) published in international refereed journals and conference proceedings. Dr. Chadli is on the editorial board (Editor, Associate Editor) of several international journals, including the IEEE Transactions on Fuzzy Systems, Automatica, the IET Control Theory and Applications, the Franklin Institute Journal, Asian Journal of Control ... and was a Guest Editor for Special Issues in international journals and Vice Dean of the Faculty of Sciences and Technologies.

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Vicenç Puig (UPC, Barcelona, Spain) received the telecommunications engineering Bsc/Msc degree in 1993 and the PhD degree in Automatic Control in 1999, both from Universitat Politècnica de Catalunya (UPC). He is Full Professor of the Automatic Control Department and a Researcher at the Institut de Robòtica i Informàtica Industrial, both from the UPC. He is currently the Director of the PhD Programme in Automatic Control and Robotics and Head of the Research Group in Advanced Control Systems at UPC. Formerly, he was the Director of the Automatic Control Department at UPC (2015-2023). He has developed important scientific contributions in the areas of fault diagnosis and fault-tolerant control using interval and linear-parameter-varying models using set-based approaches. He has participated/leaded more than 20 European and national research projects in the last decade. He has also led many private contracts with several companies and has published more than 200 journal articles and more than 500 in international conference/ workshop proceedings. He has supervised over 40 PhD dissertations and over 100 master's theses/final projects. He is currently the chair of the IFAC Safeprocess TC Committee 6.4 (2020-until now) and was the vicechair (2014–2017). He has been the general chair of the IEEE Conference on Control and Fault-Tolerant Systems (IEEE Systol 2016 and 2021) and the IPC chair of the IFAC Safeprocess 2018, IEEE EDGE 2022, IEEE MED 2023 and IEEE Systol 2025.