TERMS OF REFERENCE FOR THE R&D PROJECT 1 (LITD 34)

1. **Title of the Project**: Study of Reference architecture for Smart Manufacturing in India

2. **Background:**

a) A reference architecture is a standardized framework or blueprint that provides a structured and comprehensive design for the implementation of any system. It serves as a guide, offering a set of best practices, principles, and specifications to design and deploy integrated solutions in the context of any modern manufacturing processes.

b) Smart manufacturing refers to the use of advanced technologies and data-driven intelligence to enhance and optimize the entire manufacturing process. It involves the integration of cutting-edge technologies, such as the Internet of Things (IoT), artificial intelligence (AI), machine learning, data analytics, and automation, into traditional manufacturing systems. The goal of smart manufacturing is to create more efficient, agile, and adaptable production processes that can respond quickly to changes in demand and market conditions.

c) A reference architecture for smart manufacturing would be essential as it would provide a standardized framework and set of guidelines for the design and implementation of interconnected and intelligent manufacturing systems. This would not only facilitate seamless integration of technologies but also streamline the development process, reduce implementation risks, and accelerate innovation. Additionally, a reference architecture would serve as a common language for industry stakeholders, enabling effective communication and collaboration.

d) This research project intends to review the existing reference architectures for smart manufacturing developed by various consortiums and countries. It further aims to assess the current status of implementation of smart manufacturing across various sectors of industry of varied scales and assess the suitability of implementation of the existing reference architectures on Indian industry.

3. **Objective:** To gather technical data, assess the landscape, and create a structure of a reference architecture for smart manufacturing the context of Indian industries.

4. **Scope**:

a) Study and comparative analysis of existing literature which includes international standards such as standards published by IEC, DIN/DKE etc., research papers, SOPs/instruction/guidelines/laws applicable to smart manufacturing, any other study report available. Study of international standards may be done specifically keeping in view their suitability for implementation in Indian context.

b) Collection of the following data regarding industries where Smart manufacturing practices have been implemented in India. Similar discussion and assessment should be done with smart manufacturing solution providers in India:

i. Current state of smart manufacturing: Overview of the existing smart manufacturing landscape in India and adoption rates and maturity of smart manufacturing technologies.
ii. Industry-Specific Requirements: Analysis of specific needs and requirements across different industries and customization of reference architecture required to accommodate industry-specific challenges and opportunities.
iii. Technology Stack: Examination of the technologies involved, including IoT, AI, machine learning, data analytics, and automation. Also assess compatibility and integration of various technologies within the reference architecture.
iv. Identification and evaluation of interoperability standards for seamless communication between different components of smart manufacturing systems currently being implemented.
v. Assessment of security measures within the reference architecture to protect sensitive data.
vi. Evaluation of the existing reference architectures reviewed under literature survey for scalability to accommodate growth and changing demands and flexibility to adapt to evolving technologies and industry requirements.
vii. Identification of potential challenges and obstacles in implementing smart manufacturing reference architecture in the Indian context. Also suggest, strategies to overcome these challenges.
viii. Assessment of the economic impact of adopting smart manufacturing reference architecture, including potential cost savings, increased productivity, and job creation.
ix. Analysis of the availability of skilled professionals to implement and manage smart manufacturing systems.
x. Strategies and plans for disaster recovery, Business continuity measures in place.
xi. Development of a roadmap for the future evolution of smart manufacturing reference architecture in India.
xii. Collection of feedback from industries that have adopted smart manufacturing reference architecture.

c) Feedback from users of smart manufacturing solutions in India.

5. Research Methodology:

a) Review and analyze the literature as per the details mentioned scope.
b) Collect feedback/information through circulation of structured questionnaire.
c) During the visit to smart manufacturing industries and solution providers:
    a. Observe the facilities/solutions for collection of data.
    b. Conduct focused group discussion in a structured format.

6. Sampling Plan:

a) Two large, medium and small scale each industry shall be visited where smart manufacturing practices have been implemented.
b) Atleast two smart manufacturing solution providers should be visited for in depth-review.
c) Feedback from atleast five users shall be sought.

7. Deliverables: The following should be submitted in hard copy and digital format to BIS:

a) Study report covering all the aspects mentioned in the scope.
b) Questionnaire and response received to them.

8. Requirement for the CVs: CVs of the following members to be shared by the organization conducting the research:

a) Project leader for the R&D project.
b) Team members to be engaged for the project.

9. Timeline and Method of Progress Review:

a) The timeframe for completing the study and submission of the final report is 3 months from the date of award of the project.
a) Mid-term review of the project: Mid-term report covering the review of the literature and survey conducted to be submitted within 45 days from the date of award of the project.
b) Draft report: To be submitted with 75 days from the date of award of the project.
c) In case of delay in submission of final draft report, the justification shall be given by the project proposer for consideration by the Sectional Committee.
d) d) The proposer shall comply to the provisions given in the BIS guidelines for Research & Development Projects for Formulation and Review of Standards, i.e., **doc no. SCMD/R&D Guidelines/20230909.**
e) e) The proposer taking up the project shall clear all doubts on provisions of research including ToR and BIS guidelines before acceptance of the project and signing agreement.

10. Support BIS will Provide: Following will be provided by BIS on request

a) Any national/international standard relevant to the project.
b) Assistance by introducing researchers to third parties wherever suitable.

Contact details: Ms. Ankita Srivastava, Scientist-D and Member Secretary of LITD 34, litd@bis.gov.in

ANNEX E

OPERATION OF FUNDS AND PROGRESS REPORT

1. Title of the Project: Study of Reference architecture for Smart Manufacturing in India	Project number: LITD 0023
2.Name & Address of Project leader: Dr. A. Kala Associate Professor Department of Information Technology Sri Venkateswara College of Engineering	Date of Commencement: 29/06/2024

3. Details of Equipment Purchased (if any):

Name of equipment	**Cost (in Rs.)**	**Supplier**	**Date of purchase/ placing order for each item of equipment**
Surface Pro 10	182310	Vatanix Technologies Private Limited	Date of Purchase 09.08.2024
Programmable Logic Controller	80240	Vi Microsystems Pvt. Ltd.	Date of Placing order 12.08.2024
IoT Gateway	82305	Vi Microsystems Pvt. Ltd.	Date of Placing order 12.08.2024
Assembling kit	26255	Vi Microsystems Pvt. Ltd.	Date of Placing order 12.08.2024
IoT based manufacturing kit	30090	Vi Microsystems Pvt. Ltd.	Date of Placing order 12.08.2024

4. Fund received Rs. 2,25,450

5. Expenditure made in Rupees: (Please provide the details)

Expenditure	Amount	Taxes (as applicable)	Total
Manpower cost	12903		12903
Consumables	2356		2356
Equipment	154500	27810	182310
Travel	16616		16616
Others	1500		1500
Grand Total	187875	27810	215685

6. Amount saved (if any) from the last instalment: Rs.9765

7. Date on which scheme will complete its normal tenure of months 29-09-2024

8. Whether extension beyond normal tenure has been requested. No.

9. Constraints (if any) faced in the progress of work and suggestions to overcome them.

- **Access to Information**- Industries were hesitant to share detailed or sensitive information about their processes, technologies, and strategies.

- **Varied Technological Adoption Levels**- Different industries are at varying stages of adopting smart manufacturing technologies, making it hard to gather comparable data.

10. Any deviation from original plan with its nature and cause. NA

11. List of publication giving full bibliographic details accrued from this project(copies of the paper (s) should be enclosed). NA

3. **Summary of work done (200 words).**

- Conducted an extensive literature review, analyzing research papers on existing reference architectures for smart manufacturing. This included a comparative analysis of architectures across various sectors.
- Compile an extensive list of international standards from prominent organizations such as IEC, DIN/DKE, ISO, NIST, CEN/CENELEC
- Prepared two detailed questionnaires: one aimed at collecting data from industries/solution providers and another designed to gather feedback from users implementing smart manufacturing solutions
- The questionnaires were validated by industry experts from Hyundai Motors India Pvt. Ltd. and experts from Tamil Nadu Smart and Advanced Smart Manufacturing (TANSAM) powered by Siemens, to ensure the reliability and relevance.
- Visited the following industries/solution providers and conducted group discussions with their prominent representatives to gain deeper insights
    - Sundaram Fasteners Pvt. Ltd
    - SEW Euro Drives Pvt. Ltd
    - Hyundai Motors India Pvt. Ltd
    - JK Tyre & Industries Ltd
    - Sarang Auto Parts Pvt Ltd
    - TANSAM
    - Embridge Solutions Pvt Ltd
    - Delphi TVS Technologies Ltd
- These discussions provided a comprehensive review of current practices and challenges in smart manufacturing in India.
- Collected responses to the questionnaire from the following industries implementing smart manufacturing.

Industries/Solution Provider	Name of the Industry
Large Scale	JK Tyre & Industries Ltd Delphi TVS Technologies Ltd.
Small Scale	Sarang Auto Parts Pvt. Ltd
Solution Provider	Embridge Solutions Pvt. Ltd

- Obtained feedback from users implementing smart manufacturing technologies.

4. **Proposed programme of work for the next month (1000 words).**

Study of International Standards for Suitability in the Indian Context

- Examine international standards relevant to smart manufacturing to provide a comprehensive understanding of the current landscape.
- Conduct an in-depth study of international standards for smart manufacturing, with a specific focus on their suitability for implementation in the Indian context.
- Analyze the standards to understand its core principles, requirements, and implementation guidelines and evaluate the compatibility of these standards with the existing manufacturing infrastructure and regulatory environment in India.
- Assess the feasibility of implementing these standards in India, considering local infrastructure, regulatory environment, and industry practices.

Collection of Questionnaire Responses from Various Industries

- Plan to visit industries across various sectors in large-scale, medium-scale and small-scale industries implementing smart manufacturing.
- Connect with experts in academia to gain insights into best practices, challenges, and emerging trends in smart manufacturing.
- Gather responses through interviews and questionnaires and conduct on-site observations.
- Engage with solution providers to gather insights on the adoption and implementation of smart manufacturing practices.
- Collect feedback from end-users who are actively using smart manufacturing solutions to understand their experiences and challenges.

Detailed Analysis of Collected Responses

- Compile all responses received for the questionnaire into a central database for easy access and analysis.
- Analyze the data collected from the questionnaires using statistical tools
- Identify trends, patterns, challenges, successful practices, and the impact of smart manufacturing.
- Analyze the existing landscape, adoption rates and maturity of smart manufacturing technologies in India.
- Compare the findings across different industry scales (large, medium, small) to understand the unique challenges and opportunities.
- Explore the compatibility and integration of various technologies within the reference architecture.

- Evaluate the technological readiness and perceived benefits of smart manufacturing
- Identify common factors contributing to successful implementation and key barriers that need to be addressed.
- Analysis of the availability of skilled professionals to implement and manage smart manufacturing systems.
- Assessment of the economic impact of adopting smart manufacturing reference architecture, including potential cost savings, increased productivity, and job creation.
- Analysis of future evolution of smart manufacturing reference architecture in India.

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Report Preparation

- Prepare a detailed report about the existing reference architectures and international standards used for smart manufacturing.
- Through data collection, analysis, and stakeholder engagement, the report providesthe current state of smart manufacturing, industry-Specific Requirements,technology stack, economic impact and challenges.

5. Detailed Progress Report enlisting the objectives in beginning briefly (upto five pages maximum).

1. Existing Reference Architectures for Smart Manufacturing

- Reference architectures are designed by various industrial organizations and Standards Development Organizations (SDOs) to develop a smart manufacturing solution and promote systematic standardization.
- Some of the existing reference architectures identified from the literature review includes the following:

Reference Architecture	Developed by	Purpose	Industry Adoption	Technologies Used
RAMI 4.0 (Reference Architectural Model Industry 4.0)	Association of German Engineers (VDI) and German Electrical and Electronic Manufacturers' Association (ZVEI)	Standardization and interoperability for Industry 4.0.	Automotive and manufacturing sectors of European industries.	IoT, CPS, Data Analytics, Standardized Communication Protocols
IIRA (Industrial Internet Reference Architecture)	Industrial internet consortium (IIC)	Enhancing interoperability and flexibility in industrial internet systems.	Large industrial organizations and manufacturing companies globally.	IIoT, Edge Computing, Big Data, AI
ISA-95 (International Society of	International Society of Automation (ISA)	Manufacturing operations and enterprise integration.	Process industries such as chemicals, oil and gas, and pharmaceuticals.	MES, ERP, Industrial Control Systems

Automation)				
SMA **(Smart Manufacturing Reference Architecture)**	Industrial Internet Consortium (IIC)	Enhancing production efficiency, flexibility, and agility.	Smart manufacturing initiatives, especially in North America.	IoT, Big Data, AI, Cloud Computing
SME **(Smart Manufacturing Ecosystem)**	National Institute of Standards and Technology (NIST)	Enabling seamless data flow and communication within manufacturing.	Industries focusing on data analytics and collaborative technologies.	IoT, Data Analytics, Automation, Cloud Computing
IMSA **(Intelligent Manufacturing Systems Architecture)**	Ministry of Industry and Information Technology (MIIT) and Standardization Administration of China (SAC)	Improving manufacturing efficiency, flexibility, and responsiveness.	Advanced manufacturing sectors, particularly in Europe and Asia.	AI, Robotics, IoT, Real-time Data Analytics
IIoT-A **(Industrial Internet of Things Architecture)**	Industrial Internet Consortium (IIC)	Scalability and flexibility in industrial automation.	Industrial automation sectors, particularly in North America.	IIoT, Cloud Computing, AI, Data Integration
ISAM **(Industrial System Architecture for Manufacturing)**	Industrial Internet Consortium (IIC)	Integration and optimization of manufacturing processes and systems.	Industries with complex manufacturing processes and high integration needs.	Industrial Control Systems, IoT, Data Analytics
SITAM **(Smart Industrial Technology Architecture Model)**	Institute of Industrial Engineering (IAW) at the University of Stuttgart	Structured approach for implementing smart technologies and integrating them into existing industrial systems.	Industries adopting smart manufacturing technologies in automotive and electronics sectors.	IoT, Edge Computing, Data Analytics, Automation, Machine Learning
IoT-ARM **(Internet of Things Architecture Reference Model)**	European Telecommunications Standards Institute (ETSI)	Comprehensive framework for IoT deployments, ensuring consistent architecture and interoperability across different	Various industries, including smart cities, healthcare, and industrial automation, for implementing IoT solutions.	IoT, Cloud Computing, Big Data, Connectivity Protocols (e.g., MQTT, CoAP)

		IoT systems.		

2. International standards relevant to smart manufacturing

2.1 IEC standards for smart manufacturing

The International Electrotechnical Commission (IEC) standards support the development of smart manufacturing environments by addressing various aspects such as integration, cybersecurity, data exchange, lifecycle management, and safety.

Standard	Title	Description
IEC 62264	Enterprise-Control System Integration	Provides standards for the integration of enterprise and control systems, defining the flow of information between business logistics systems and manufacturing control systems.
IEC 62443	Industrial Cyber Security	Focuses on cybersecurity for industrial automation and control systems (IACS), offering guidelines to protect systems from cyber threats
IEC 61512	Batch Control	Defines models and terminology for batch control, providing a framework for the design and operation of batch processes in manufacturing
IEC 61499	Function Blocks for Industrial-Process Measurement and Control Systems	Provides a standard for distributed industrial automation, focusing on function blocks and their use in distributed systems for improved flexibility and reconfigurability
IEC 62541	OPC Unified Architecture (OPC UA)	Specifies a platform-independent standard for communication of industrial automation data, ensuring seamless data exchange across diverse systems.
IEC 62890	Lifecycle Management for Systems and Products Used in Industrial-Process Measurement, Control, and Automation	Offers guidelines for managing the lifecycle of industrial systems and products, from initial design to decommissioning
IEC 61131	Programmable Controllers	Provides standards for programmable controllers, including their programming languages, operational behavior, and system integration
IEC 62061	Safety of Machinery – Functional Safety of Safety-Related Electrical, Electronic and Programmable Electronic Control Systems	Specifies requirements and guidelines for the design and integration of safety-related control systems in machinery.
IEC 61360	Common Data Dictionary Specification	Defines a common data dictionary for industrial automation, facilitating the standardization and exchange of product data.

2.2 DIN/DKE standards for smart manufacturing

The International standards from DIN (German Institute for Standardization) and DKE (German Commission for Electrical, Electronic & Information Technologies) ensure the effective implementation of smart manufacturing practices, enhance system safety and security, improve energy efficiency, and achieve better performance and interoperability

Standard	Title	Description
DIN EN 62443	Security for industrial automation and control systems	Focuses on cybersecurity for industrial automation and control systems, offering guidelines to protect systems from cyber threats.
DIN EN 62061	Safety of Machinery – Functional Safety of Safety-Related Electrical, Electronic and Programmable Electronic Control Systems	Specifies requirements for the design, integration, and validation of safety-related electrical, electronic, and programmable control systems in machinery
DIN EN ISO 50001	Energy Management Systems	Specifies requirements for establishing, implementing, maintaining, and improving an energy management system to enhance energy performance
DIN EN ISO 13849	Safety of Machinery – Safety-Related Parts of Control Systems	Provides guidelines for the design and validation of safety-related parts of control systems in machinery, ensuring reliability and safety
DIN EN ISO 22400	Automation Systems and Integration – Key Performance Indicators (KPIs) for Manufacturing Operations Management	Provides standards for defining, exchanging, and using KPIs in manufacturing operations to improve decision-making and efficiency
DIN EN ISO 19440	Enterprise Integration – Constructs for Enterprise Modelling	Specifies constructs for enterprise modeling, enhancing the integration and interoperability of enterprise systems
DIN EN ISO 15745	Industrial Automation Systems and Integration – Open Systems Application Integration Framework	Specifies frameworks for the integration of industrial automation systems, promoting interoperability and flexibility
DIN EN ISO/IEC 27001	Information Security Management Systems	Provides requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS).

2.3 ISO standards for smart manufacturing

The International Organization for Standardization (ISO) standardsenable to enhance the efficiency, safety, sustainability, and resilience of the smart manufacturing operations, thereby improving their competitiveness in the global market.

Standard	Title	Description
ISO 22400	Automation Systems and Integration – Key Performance Indicators (KPIs) for Manufacturing Operations Management	Provides standards for defining, exchanging, and using KPIs in manufacturing operations to improve decision-making and efficiency.
ISO 15745	Industrial Automation Systems and Integration – Open Systems Application Integration Framework	Specifies frameworks for the integration of industrial automation systems, promoting interoperability and flexibility
ISO 50001	Energy Management Systems	Specifies requirements for establishing, implementing, maintaining, and improving an energy management system to improve energy performance
ISO 20140	Automation Systems and Integration – Evaluating Energy Efficiency and Other Factors of Manufacturing Systems That Influence the Environment	Provides a framework for evaluating the energy efficiency and environmental impact of manufacturing systems
ISO 10303 (STEP)	Standard for the Exchange of Product Model Data	Specifies a standard for the computer-interpretable representation and exchange of product manufacturing information
ISO 14001	Environmental Management Systems	Specifies requirements for an effective environmental management system, ensuring sustainable manufacturing practices
ISO 13849	Safety of Machinery – Safety-Related Parts of Control Systems	Provides guidelines for the design and integration of safety-related parts of control systems in machinery
ISO 19439	Enterprise Integration – Framework for Enterprise Modelling	Provides a framework for enterprise modeling, enhancing the integration and interoperability of enterprise systems
ISO 11354	Advanced Automation – General Requirements for Systems Integration	Specifies general requirements for systems integration in advanced automation, promoting interoperability and modularity
ISO/IEC 27001	Information Security Management Systems	Provides requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS)
ISO 22301	Business Continuity Management Systems	Specifies requirements for a management system to protect against, reduce the likelihood of, and ensure recovery from disruptive incidents
ISO 31000	Risk Management – Guidelines	Provides guidelines on risk management, ensuring effective risk assessment and mitigation strategies in manufacturing

2.4 NIST standards for smart manufacturing

The National Institute of Standards and Technology (NIST) provides several standards and guidelines that enhance the cybersecurity posture, ensure interoperability and integration of advanced systems, and optimize performance and efficiency in the manufacturing operations.

Standard	Title	Description
NIST SP 800-82	Guide to Industrial Control Systems (ICS) Security	Provides guidelines for securing Industrial Control Systems, addressing security risks, vulnerabilities, and mitigation strategies for ICS environments
NIST SP 800-53	Security and Privacy Controls for Information Systems and Organizations	Outlines security and privacy controls to protect organizational operations, assets, and individuals by ensuring effective security measures.
NIST SP 800-171	Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations	Provides guidelines for protecting controlled unclassified information (CUI) in non-federal systems, ensuring confidentiality and integrity.
NIST SP 1800-10	Protecting Information and System Integrity in Industrial Control System Environments	Offers practical guidance on improving the security and integrity of industrial control systems, focusing on reducing vulnerabilities and enhancing resilience.
NIST SP 800-184	Guide for Cybersecurity Event Recovery	Provides a framework for effective recovery from cybersecurity events, ensuring continuity of operations and minimizing impact.
NIST IR 8183	Cybersecurity Framework Manufacturing Profile	Tailors the NIST Cybersecurity Framework to the manufacturing sector, providing a risk-based approach to managing cybersecurity threats.
NIST SP 1500-201	Framework for Cyber-Physical Systems	Establishes a comprehensive framework for the development and integration of cyber-physical systems, ensuring interoperability and security.
NIST SP 800-37	Risk Management Framework for Information Systems and Organizations	Provides guidelines for applying the Risk Management Framework to federal information systems, emphasizing risk assessment, mitigation, and monitoring.

2.5 CEN/CENELEC standards for smart manufacturing

The international standards from CEN (European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization can ensure the safety, security, interoperability, and efficiency of the smart manufacturing operations, thereby enhancing the competitiveness and compliance of organizations with international best practices.

Standard	Title	Description
EN 62061	Safety of Machinery – Functional Safety of Safety-Related Electrical, Electronic and Programmable Electronic Control Systems	Specifies requirements for the design, integration, and validation of safety-related electrical, electronic, and programmable control systems in machinery.
EN61360	Standard Data Elements Types with Associated Classification Scheme	Provides a standardized data dictionary for industrial automation, facilitating the exchange and integration of product data.
EN ISO 12100	Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction	Establishes principles for the design of safe machinery, including risk assessment and risk reduction measures.
EN ISO 13849	Safety of Machinery – Safety-Related Parts of Control Systems	Provides guidelines for the design and validation of safety-related parts of control systems in machinery, ensuring reliability and safety.
EN ISO 50001	Energy Management Systems	Specifies requirements for establishing, implementing, maintaining, and improving an energy management system to enhance energy performance.
EN 10218	Steel Wire and Wire Products – General – Part 1: Test Methods	Standardizes test methods for steel wire and wire products, ensuring consistency and quality in production.
EN ISO 22400	Automation Systems and Integration – Key Performance Indicators (KPIs) for Manufacturing Operations Management	Provides standards for defining, exchanging, and using KPIs in manufacturing operations to improve decision-making and efficiency.
EN ISO 19440	Enterprise Integration – Constructs for Enterprise Modelling	Specifies constructs for enterprise modeling, enhancing the integration and interoperability of enterprise systems.
EN ISO 15745	Industrial Automation Systems and Integration – Open Systems Application Integration Framework	Specifies frameworks for the integration of industrial automation systems, promoting interoperability and flexibility.
EN ISO/IEC 27001	Information Security Management Systems	Provides requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS).

Signature of Project leader

Date: 13-08-2024

J.K. RAMASWAMY & ASSOCIATES
Chartered Accountants

Office : 24/A, Perumal Koil Street,
Porur, Chennai - 600 116.
Mobile : 9003295909 / 7305245757 / 9841074757
E-mail : jk_ramaswamy@yahoo.com
jkramaswamy1990@gmail.com

UTILIZATION CERTIFICATE

Sri Venkateswara College of Engineering

BIS- SCMD/R&D Project

LITD 0023 - Study of Reference architecture for Smart Manufacturing in India

This is to certify that the First Instalment of Grants received from Bureau of Indian Standards dated on 15th July 2024 & Credited for an amount of Rs. 2,25,450/- on 29th June 2024 has been spent towards the following purposes: -

Statement of Expenditure

S.No	Expenditure	Amount (in Rs)
1	Manpower Cost	12,903
2	Consumables	2,356
3	Equipments	1,82,310
4	Travel	16,616
5	Any other/Overhead expenses	1,500
Grand Total		**2,15,685**

The same has been verified and found to be correct as per information and records furnished before us.

PLACE: Chennai.
DATE : 13.08.2024

AS PER INFORMATION FURNISHED
For **J.K. RAMASWAMYAND ASSOCIATES**
CHARTERED ACCOUNTANTS
(FRN: 002972S)

(J.K. RAMASWAMY)
PROPRIETOR
(M.NO.: 029042)

J.K. RAMASWAMY & ASSOCIATES CHARTERED ACCOUNTANTS FRN No.002972-S PORUR Chennai-600116 M.No.029042 Ph:24828125

UDIN : 24029042BKELZK8846

SVCE | Sri Venkateswara College of Engineering
Autonomous Institution, Affiliated to Anna University, Chennai.
Approved by the A.I.C.T.E, Accredited by NAAC
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14/08/2024

BIS SCMD/R&D PROJECT

LITD 0023 -Study of Reference architecture for Smart Manufacturing in India

Statement of the Equipments Purchased out of first installment

S.No	Name of the equipment	Cost (in Rs.)	Date of Purchase	Name of the supplier	Purpose of the equipment
1	Surface Pro 10	1,82,310	09-08-2024	Vatanix Technologies Private Limited	• Enables on-site analysis, data collection, and real-time feedback during visits to various smart manufacturing industries. • Facilitates seamless communication with IoT devices, sensors, and other smart manufacturing equipment. • Functions as a Human-Machine Interface, serving as a control panel for automation systems in smart manufacturing.

A. Kala 14/8/24
Signature of the Project Leader

Dr. A. KALA, M.E., Ph.D
Associate Professor
Department of Information Technology
Sri Venkateswara College of Engineering
Sriperumbudur - 602 117.

14/8/24
Signature of the Head of the Institution

Prof.S. Ganesh Vaidyanathan, Ph.D
Principal
Sri Venkateswara College of Engineering
Pennalur, Sriperumbudur Tk-602 117,
Tamilnadu State, India.

GFR 12 – A

[(See Rule 238 (1)]

FORM OF UTILIZATION CERTIFICATE FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE FOR THE YEAR **2024** in respect
of recurring/non-recurring
GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the Scheme **SCMD/R&D Projects**
2. Whether recurring or non-recurring grants **Non-recurring**
3. Grants position at the beginning of the Financial year
   (i) Cash in Hand/Bank **0**
   (ii) Unadjusted advances **0**
   (iii) Total **0**
4. Details of grants received, expenditure incurred and closing balances: (Actuals)

Unspent Balances ofGrants received years [figure as atSl. No. 3 (iii)]	Interest Earned thereon	Interest deposited back to the Govern-ment	Grant received duringthe year			Total Availabl efunds (1+2-3+4)	Expenditure incurred	Closing Balances (5-6)
1	2	3	4			5	6	7
			Sanction No. (i)	Date (ii)	Amount (iii)			
0	34	0	LITD 0023	29-06-2024	225450	225484	215685	9799

Component wise utilization of grants:

Grant-in-aid–General	Grant-in-aid–Salary	Grant-in-aid–creation of capital assets	Total
20472	12903	182310	215685

Details of grants position at the end of the year

(i) Cash in Hand/Bank **9799**
(ii) Unadjusted Advances **0**
(iii) Total **9799**

GENERAL FINANCIAL RULES 2017
Ministry of Finance
Department of Expenditure

FORM GFR 12A

Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

(i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

(ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

(iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.

(iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.

(v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

(vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

(vii) It has been ensured that the physical and financial performance under SCMD / R & D Project (name of the scheme has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given at Annexure – I duly enclosed.

(viii) The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.)

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Date: 14-08-2024
Place: Sriperumbudur

Signature N. Vasudevan

Name N. VASUDEVAN
Chief Finance Officer
(Head of the Finance)

Signature S Ganesh 14/8/24

Name.....
Head of the Organisation

Prof.S. Ganesh Vaidyanathan, Ph.D
Principal
Sri Venkateswara College of Engineering
Pennalur, Sriperumbudur Tk-602 117.
Tamilnadu State, India.

(Strike out inapplicable terms)

FINANCE EXECUTIVE
Sri Venkateswara College of Engineering
Pennalur, Sriperumbudur Tk-602 117
Tamilnadu, India

A. Kale
14/8/24

SVCE | Sri Venkateswara College of Engineering

Autonomous Institution, Affiliated to
Anna University, Chennai
Approved by the AICTE, Accredited by NAAC

Department of Information Technology

Project Number : LITD 0023

Project Title : Study of Reference Architecture for Smart Manufacturing in India

Feedback from Users

User Information	
Name	
Address	
Company/Organization	
Position/Role	
Email	
Phone Number	

Place **Signature**

1. How long have you been using smart manufacturing solutions?

- ☐ 6-12 months
- ☐ 1-2 Years
- ☐ 2-3 Years
- ☐ 3-4 Years
- ☐ Over 4 years

2. Which of the smart manufacturing solutions are you using?

- ☐ IoT Devices
- ☐ Data Analytics Tools
- ☐ Automation Systems
- ☐ Cloud Platforms
- ☐ AI/ML Integration
- ☐ Other: _____

3. How would you rate the ease of use of smart manufacturing solutions?

- ☐ Very Easy
- ☐ Easy
- ☐ Neutral
- ☐ Difficult
- ☐ Very Difficult

4.How would you rate the performance and reliability of smart manufacturing solutions?

- ☐ Excellent
- ☐ Good
- ☐ Average
- ☐ Poor
- ☐ Very Poor

5. Have you experienced any technical issues or downtime?

- ☐ Yes (please specify): _____
- ☐ No

6. How quickly were any issues resolved?

- ☐ Very Quickly

- ☐ Quickly
- ☐ Average
- ☐ Slowly
- ☐ Very Slowly

7. How satisfied are you with the functionality of smart manufacturing solutions?

- ☐ Very Satisfied
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very Dissatisfied

8. Are there any features you find particularly useful? Please specify.

9. Are there any features you feel are missing or could be improved? Please specify.

10. Any additional comments or suggestions

SVCE | Sri Venkateswara College of Engineering

Autonomous Institution, Affiliated to
Anna University, Chennai
Approved by the AICTE, Accredited by NAAC

Department of Information Technology

Project Number : LITD 0023

Project Title : Study of Reference Architecture for Smart Manufacturing in India

Feedback from Users

User Information	
Name	
Address	
Company/Organization	
Position/Role	
Email	
Phone Number	

Place **Signature**

1. How long have you been using smart manufacturing solutions?

Less than 3 months
3-6 months
6-12 months
Over 1 year

2. Which of the smart manufacturing solutions are you using?

IoT Devices
Data Analytics Tools
Automation Systems
Cloud Platforms
AI/ML Integration
Other: _____

3. How would you rate the ease of use of smart manufacturing solutions?

Very Easy
Easy
Neutral
Difficult
Very Difficult

4.How would you rate the performance and reliability of smart manufacturing solutions?

Excellent
Good
Average
Poor
Very Poor

5. Have you experienced any technical issues or downtime?

Yes (please specify): _____
No

6. How quickly were any issues resolved?

Very Quickly
Quickly

Average
Slowly
Very Slowly

7. How satisfied are you with the functionality of smart manufacturing solutions?

Very Satisfied
Satisfied
Neutral
Dissatisfied
Very Dissatisfied

8. Are there any features you find particularly useful? Please specify.

9. Are there any features you feel are missing or could be improved? Please specify.

10. Any additional comments or suggestions

Sri Venkateswara College of Engineering

Autonomous Institution, Affiliated to Anna University, Chennai
Approved by the AICTE, Accredited by NAAC

Department of Information Technology

Project Number : LITD 0023

Project Title : Study of Reference Architecture for Smart Manufacturing in India

Questionnaire

General Information			
Company Name			
Address			
Industry Sector	[ ] Automotive	[ ] Electronics	[ ] Pharmaceuticals
	[ ] Textiles	[ ] Food and Beverage	[ ] Energy and Utilities
	[ ] Automation	[ ] Manufacturing	
	[ ] Other: _____		
Products			
Location			
Number of Employees			
Name of Respondent			
Position			
Contact	Email:	Phone Number:	

Station **Signature**

I. Current state of smart manufacturing

1. How would you define 'smart manufacturing' in the context of your organization?
   Fully Automated Production
   Integrated Data and Connectivity
   Predictive Maintenance
   Others: _____

2. How would you describe the current adoption level of smart manufacturing technologies in your industry?
   Low
   Moderate
   High

3. Which of the following smart manufacturing technologies does your organization currently utilize?
   Industrial IoT (IIoT)
   Big Data Analytics
   Artificial Intelligence (AI) and Machine Learning (ML)
   Robotics and Automation
   Additive Manufacturing (3D Printing)
   Cloud Computing
   Cybersecurity Solutions for Manufacturing
   Others: _____

4. Has your organization adopted any reference architecture or frameworks for smart manufacturing?
   Yes
   No
   - If yes, please specify:
   ISA-95
   RAMI 4.0
   IIRA
   Others: _____

5. What are the primary challenges faced for the adoption of smart manufacturing in your organization?
   High initial investment costs
   Lack of skilled workforce
   Integration complexities with existing systems
   Concerns about data security and privacy
   Resistance to change among employees
   Others: _____

6. How mature are your organization's smart manufacturing initiatives?
   - Early stage (exploring technologies)
   - Intermediate stage (piloting solutions)
   - Advanced stage (fully integrated and optimized)

7. What are your organization's plans for future investments in smart manufacturing technologies?
   - Increase Investments
   - Maintain Current Investments
   - Decrease Investments

II. Industry-Specific Requirements:

8. What are the unique needs and requirements of your industry that influenced the implementation of smart manufacturing practices?
   - Regulatory Requirements
   - Customer Demands
   - Operational Efficiency
   - Cost Reduction
   - Quality Improvement
   - Sustainability
   - Others:_____

9. How has the reference architecture been customized to meet your industry-specific requirements?
   - Technology Integration
   - Workflow Processes
   - Compliance with Regulations
   - Others:_____

10. What industry-specific opportunities have been realized through the customization of the reference architecture?
    - Improved Efficiency
    - Cost Reduction
    - Enhanced Product Quality
    - Others:_____

III. Technology stack

11. Which of the following smart manufacturing technologies does your organization currently utilize?
    - Industrial IoT (IIoT)
    - Data Analytics
    - Artificial Intelligence (AI) and Machine Learning (ML)
    - Robotics and Automation

Additive Manufacturing (3D Printing)
Cloud Computing
Cybersecurity Solutions
Others: _____

12. What are the primary challenges your organization faces in integrating various smart manufacturing technologies into a cohesive system?

Compatibility issues between different technologies
Data interoperability and standardization
Scalability of solutions
Technical expertise and skills gap
Cost of implementation and maintenance
Regulatory compliance requirements
Others: _____

13. How often does your organization conduct compatibility testing when integrating new technologies into your existing smart manufacturing framework?

Regularly
Occasionally
Rarely

14. Which emerging technologies do you plan to invest in within the next 2-3 years for enhancing your smart manufacturing capabilities?

Edge Computing
Digital Twins
Blockchain for Supply Chain
Augmented Reality (AR) and Virtual Reality (VR)
Others: _____

IV. Interoperability Standards

15. Which interoperability standards or protocols does your organization currently adhere to for smart manufacturing systems?

OPC UA (Open Platform Communications Unified Architecture)
MQTT (Message Queuing Telemetry Transport)
AMQP (Advanced Message Queuing Protocol)
RESTful APIs (Representational State Transfer)
DDS (Data Distribution Service)
CoAP (Constrained Application Protocol)
Others: _____

16. What are the primary challenges your organization faces regarding interoperability in smart manufacturing systems?

Lack of standardized data formats
Integration complexity between different vendor systems
Security concerns related to data exchange
Scalability issues with interoperability solutions
Limited support for legacy systems
Others: _____

17. Which areas of smart manufacturing do you believe require further standardization efforts for improved interoperability?

IoT device communication protocols
Data exchange formats and semantics
Integration of AI and machine learning algorithms
Cybersecurity standards for interconnected systems
Cross-platform compatibility for automation systems
Others: _____

V. Security Measures

18. Which security measures does your organization currently employ within the smart manufacturing environment?

Encryption of data in transit (e.g., SSL/TLS)
Encryption of data at rest (e.g., AES)
Role-based access control (RBAC)
Network segmentation and firewall protection
Intrusion detection and prevention systems (IDPS)
Endpoint security (e.g., antivirus, anti-malware)
Continuous monitoring and auditing
Others: _____

19.How does your organization ensure the protection of sensitive data (e.g., intellectual property, customer information) in smart manufacturing systems?

Data anonymization and pseudonymization techniques
Regular data backups and disaster recovery plans
Compliance with data protection regulations (e.g., GDPR, CCPA)
Secure data deletion practices
Others: _____

20. What are the primary cybersecurity threats that your organization faces within the smart manufacturing environment?

Malware and ransomware attacks
Insider threats (e.g., unauthorized access by employees)
Phishing and social engineering attacks
Supply chain vulnerabilities
DDoS (Distributed Denial of Service) attacks
Zero-day exploits and vulnerabilities
Others: _____

21. How does your organization monitor and respond to security incidents within the smart manufacturing systems?

Automated incident detection and response systems
Security information and event management (SIEM) tools
Regular security audits and penetration testing
Employee awareness and training programs
Others: _____

22. How does your organization ensure compliance with cybersecurity standards and regulations specific to smart manufacturing?

Adherence to industry-specific standards (e.g., NIST, ISO 27001)
Regular cybersecurity assessments and audits
Integration of security into the development lifecycle (DevSecOps)
Engagement with regulatory bodies and industry associations
Others: _____

VI. Evaluation of existing Reference Architecture

23. Which reference architecture is adopted in your organization?

RAMI 4.0
Industrial Internet Reference Architecture (IIRA)
Smart Manufacturing Ecosystem (SME)
Others: _____

24. How well does the reference architecture support the integration of additional manufacturing units?

Excellent
Good
Average
Poor
Very Poor

25. Can the reference architecture effectively manage increased data volumes from additional sensors and IoT devices?

Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

26. Evaluate the flexibility of the reference architecture in adapting to new technologies (e.g., AI, ML)

Highly flexible
Moderately flexible
Neutral
Slightly flexible
Not flexible

VII. Challenges and strategies to overcome these challenges

27. What are the primary challenges faced in integrating existing manufacturing technologies with smart manufacturing solutions?

Compatibility issues
Lack of skilled personnel
High initial investment costs
Regulatory constraints
Others: _____

28. What regulatory or compliance issues do you foresee as potential obstacles to implementing smart manufacturing in India?

Lack of clear guidelines
Stringent regulatory requirements
Compliance costs
Others: _____

29. How prepared is the current workforce in India for adopting and utilizing smart manufacturing technologies?

Highly skilled
Moderately skilled
Needs significant training
Not skilled at all

30. How can infrastructure challenges for smart manufacturing in India be overcome?

Government investment in infrastructure
Public-private partnerships

Subsidies or incentives for infrastructure development
Others: _____

VIII. Economic Impact

31. How aware are you about the potential benefits of smart manufacturing?
    Very Aware
    Somewhat Aware
    Neutral
    Not Aware

32. What do you perceive as the potential cost savings from implementing smart manufacturing technologies?
    Significant cost savings (more than 20%)
    Moderate cost savings (10-20%)
    Minimal cost savings (less than 10%)
    No cost savings expected
    Unsure

33. How do you expect smart manufacturing technologies to impact productivity in your organization or industry?
    Significant increase (more than 20%)
    Moderate increase (10-20%)
    Slight increase (less than 10%)
    No impact on productivity
    Unsure

34. What is your expectation regarding job creation or workforce impact due to smart manufacturing adoption?
    Significant job creation
    Some job creation
    No impact on jobs
    Potential job losses
    Unsure

IX. Availability of skilled professionals

35. How would you rate the current skill level of your organization or industry in terms of implementing and managing smart manufacturing systems?
    Highly skilled
    Moderately skilled
    Basic skills with room for improvement
    Insufficient skills
    Unsure

36. What specific skills do you believe are lacking in your organization or industry for effectively implementing smart manufacturing systems?

Data analytics and interpretation
IoT (Internet of Things) integration and management
Automation and robotics expertise
Cybersecurity for smart manufacturing
Others: _____

37. What specific types of training programs would you consider most beneficial for enhancing skills in smart manufacturing technologies?

Technical workshops and hands-on training
Certification courses in relevant technologies
Collaboration with educational institutions for specialized courses
On-the-job training and mentoring programs
Others: _____

38. What skills do you anticipate will be most crucial in the next 5 years for managing and advancing smart manufacturing systems in your organization or industry?

AI and machine learning for predictive maintenance
Advanced robotics and automation
Cloud computing and edge computing
Supply chain integration and optimization
Others: _____

39. How can the government and industry collaborate to improve the availability of skilled professionals in smart manufacturing?

Increased funding for training programs
Developing standardized curricula for smart manufacturing
Establishing more industry-led training centers
Providing incentives for upskilling current workforce

X. Strategies and plan for disaster recovery

40. Does your organization have a documented disaster recovery plan specifically tailored for smart manufacturing systems?

Yes, fully documented and regularly updated
Yes, documented but needs updating
No, not yet developed

41. Which of the following risks are considered in your disaster recovery and business continuity plans?

Natural disasters (e.g., earthquakes, floods)

Cybersecurity incidents (e.g., data breaches, ransomware)
Equipment failures
Supply chain disruptions
Power outages

42. Have you identified and prioritized critical smart manufacturing systems that require immediate recovery in case of a disaster?
    Yes, all critical systems are identified and prioritized
    Some critical systems are identified, but priorities need reassessment
    No, critical systems identification is not completed

43. How often do you conduct testing or simulations of your disaster recovery and business continuity plans?
    Quarterly or more frequently
    Annually
    Every 2-3 years
    Plans are not tested or simulated

44. Do you provide regular training to employees on disaster response procedures and their roles in business continuity?
    Yes, comprehensive training is provided regularly
    Training is provided occasionally
    No formal training program in place

45. To what extent are advanced technologies (e.g., AI for predictive analysis, IoT for real-time monitoring) integrated into your disaster recovery and business continuity strategies?
    Fully integrated
    Partially integrated
    Not integrated yet

46. How often do you review and update your disaster recovery and business continuity plans to incorporate lessons learned and emerging risks?
    Continuously, with regular updates
    Annually
    Every 2-3 years
    Plans are rarely updated

XI. Road map for future evolution

47. How would you describe the current state of smart manufacturing reference architecture adoption in India?
    Well-established with widespread adoption
    Growing, but still in early stages

Limited adoption with room for growth
Not aware of any existing initiatives

48. Which components do you consider essential for a robust smart manufacturing reference architecture?

Interoperability standards
Data analytics and AI integration
Cybersecurity frameworks
Cloud computing infrastructure
Edge computing capabilities
Others: _____

49. What aspects should be prioritized in the roadmap for the future evolution of smart manufacturing reference architecture in India?

Standardization of protocols and interfaces
Enhancing scalability and flexibility
Incorporating advanced AI and machine learning capabilities
Strengthening cybersecurity measures
Promoting sustainability and energy efficiency

50. Which emerging technologies do you believe will have the most significant impact on the evolution of smart manufacturing reference architectures in the next decade?

5G and next-gen communication technologies
Digital twins and virtual modeling
Autonomous robotics and drones
Blockchain for supply chain transparency
Others: _____

Sri Venkateswara College of Engineering

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Department of Information Technology

Project Number : LITD 0023

Project Title : Study of Reference Architecture for Smart Manufacturing in India

Questionnaire

General Information			
Company Name			
Address			
Industry Sector	[ ] Automotive	[ ] Electronics	[ ] Pharmaceuticals
	[ ] Textiles	[ ] Food and Beverage	[ ] Energy and Utilities
	[ ] Automation	[ ] Manufacturing	
	[ ] Other: _____		
Products			
Location			
Number of Employees			
Name of Respondent			
Position			
Contact	Email:	Phone Number:	

Station **Signature**

I. Current state of smart manufacturing

1. How would you define 'smart manufacturing' in the context of your organization?
    - ☐ Fully Automated Production
    - ☐ Integrated Data and Connectivity
    - ☐ Predictive Maintenance
    - ☐ Others: _____

2. How would you describe the current adoption level of smart manufacturing technologies in your industry?
    - ☐ Low
    - ☐ Moderate
    - ☐ High

3. Which of the following smart manufacturing technologies does your organization currently utilize?
    - ☐ Industrial IoT (IIoT)
    - ☐ Big Data Analytics
    - ☐ Artificial Intelligence (AI) and Machine Learning (ML)
    - ☐ Robotics and Automation
    - ☐ Additive Manufacturing (3D Printing)
    - ☐ Cloud Computing
    - ☐ Cybersecurity Solutions for Manufacturing
    - ☐ Others: _____

4. Has your organization adopted any reference architecture or frameworks for smart manufacturing?
    - ☐ Yes
    - ☐ No
        - If yes, please specify:
    - ☐ ISA-95
    - ☐ RAMI 4.0
    - ☐ IIRA
    - ☐ Others: _____

5. What are the primary challenges faced for the adoption of smart manufacturing in your organization?
    - ☐ High initial investment costs
    - ☐ Lack of skilled workforce
    - ☐ Integration complexities with existing systems
    - ☐ Concerns about data security and privacy
    - ☐ Resistance to change among employees
    - ☐ Others: _____

6. How mature are your organization's smart manufacturing initiatives?
    - ☐ Early stage (exploring technologies)
    - ☐ Intermediate stage (piloting solutions)
    - ☐ Advanced stage (fully integrated and optimized)

7. What are your organization's plans for future investments in smart manufacturing technologies?
    - ☐ Increase Investments
    - ☐ Maintain Current Investments
    - ☐ Decrease Investments

II. Industry-Specific Requirements:

8. What are the unique needs and requirements of your industry that influenced the implementation of smart manufacturing practices?
    - ☐ Regulatory Requirements
    - ☐ Customer Demands
    - ☐ Operational Efficiency
    - ☐ Cost Reduction
    - ☐ Quality Improvement
    - ☐ Sustainability
    - ☐ Others:_____

9. How has the reference architecture been customized to meet your industry-specific requirements?
    - ☐ Technology Integration
    - ☐ Workflow Processes
    - ☐ Compliance with Regulations
    - ☐ Others:_____

10. What industry-specific opportunities have been realized through the customization of the reference architecture?
    - ☐ Improved Efficiency:
    - ☐ Cost Reduction:
    - ☐ Enhanced Product Quality:
    - ☐ Others:_____

III. Technology stack

11. Which of the following smart manufacturing technologies does your organization currently utilize?
    - ☐ Industrial IoT (IIoT)
    - ☐ Data Analytics
    - ☐ Artificial Intelligence (AI) and Machine Learning (ML)

- ☐ Robotics and Automation
- ☐ Additive Manufacturing (3D Printing)
- ☐ Cloud Computing
- ☐ Cybersecurity Solutions
- ☐ Others: _____

12. What are the primary challenges your organization faces in integrating various smart manufacturing technologies into a cohesive system?
    - ☐ Compatibility issues between different technologies
    - ☐ Data interoperability and standardization
    - ☐ Scalability of solutions
    - ☐ Technical expertise and skills gap
    - ☐ Cost of implementation and maintenance
    - ☐ Regulatory compliance requirements
    - ☐ Others: _____

13. How often does your organization conduct compatibility testing when integrating new technologies into your existing smart manufacturing framework?
    - ☐ Regularly
    - ☐ Occasionally
    - ☐ Rarely

14. Which emerging technologies do you plan to invest in within the next 2-3 years for enhancing your smart manufacturing capabilities?
    - ☐ Edge Computing
    - ☐ Digital Twins
    - ☐ Blockchain for Supply Chain
    - ☐ Augmented Reality (AR) and Virtual Reality (VR)
    - ☐ Others: _____

IV. Interoperability Standards

15. Which interoperability standards or protocols does your organization currently adhere to for smart manufacturing systems?
    - ☐ OPC UA (Open Platform Communications Unified Architecture)
    - ☐ MQTT (Message Queuing Telemetry Transport)
    - ☐ AMQP (Advanced Message Queuing Protocol)
    - ☐ RESTful APIs (Representational State Transfer)
    - ☐ DDS (Data Distribution Service)
    - ☐ CoAP (Constrained Application Protocol)
    - ☐ Others: _____

16. What are the primary challenges your organization faces regarding interoperability in smart manufacturing systems?

- ☐ Lack of standardized data formats
- ☐ Integration complexity between different vendor systems
- ☐ Security concerns related to data exchange
- ☐ Scalability issues with interoperability solutions
- ☐ Limited support for legacy systems
- ☐ Others: _____

17. Which areas of smart manufacturing do you believe require further standardization efforts for improved interoperability?

- ☐ IoT device communication protocols
- ☐ Data exchange formats and semantics
- ☐ Integration of AI and machine learning algorithms
- ☐ Cybersecurity standards for interconnected systems
- ☐ Cross-platform compatibility for automation systems
- ☐ Others: _____

V. Security Measures

18. Which security measures does your organization currently employ within the smart manufacturing environment?

- ☐ Encryption of data in transit (e.g., SSL/TLS)
- ☐ Encryption of data at rest (e.g., AES)
- ☐ Role-based access control (RBAC)
- ☐ Network segmentation and firewall protection
- ☐ Intrusion detection and prevention systems (IDPS)
- ☐ Endpoint security (e.g., antivirus, anti-malware)
- ☐ Continuous monitoring and auditing
- ☐ Others: _____

19.How does your organization ensure the protection of sensitive data (e.g., intellectual property, customer information) in smart manufacturing systems?

- ☐ Data anonymization and pseudonymization techniques
- ☐ Regular data backups and disaster recovery plans
- ☐ Compliance with data protection regulations (e.g., GDPR, CCPA)
- ☐ Secure data deletion practices
- ☐ Others: _____

20. What are the primary cybersecurity threats that your organization faces within the smart manufacturing environment?

- ☐ Malware and ransomware attacks

- ☐ Insider threats (e.g., unauthorized access by employees)
- ☐ Phishing and social engineering attacks
- ☐ Supply chain vulnerabilities
- ☐ DDoS (Distributed Denial of Service) attacks
- ☐ Zero-day exploits and vulnerabilities
- ☐ Others: _____

21. How does your organization monitor and respond to security incidents within the smart manufacturing systems?

- ☐ Automated incident detection and response systems
- ☐ Security information and event management (SIEM) tools
- ☐ Regular security audits and penetration testing
- ☐ Employee awareness and training programs
- ☐ Others: _____

22. How does your organization ensure compliance with cybersecurity standards and regulations specific to smart manufacturing?

- ☐ Adherence to industry-specific standards (e.g., NIST, ISO 27001)
- ☐ Regular cybersecurity assessments and audits
- ☐ Integration of security into the development lifecycle (DevSecOps)
- ☐ Engagement with regulatory bodies and industry associations
- ☐ Others: _____

VI. Evaluation of existing Reference Architecture

23. Which reference architecture is adopted in your organization?

- ☐ RAMI 4.0
- ☐ Industrial Internet Reference Architecture (IIRA)
- ☐ Smart Manufacturing Ecosystem (SME)
- ☐ Others: _____

24. How well does the reference architecture support the integration of additional manufacturing units?

- ☐ Excellent
- ☐ Good
- ☐ Average
- ☐ Poor
- ☐ Very Poor

25. Can the reference architecture effectively manage increased data volumes from additional sensors and IoT devices?

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

26. Evaluate the flexibility of the reference architecture in adapting to new technologies (e.g., AI, ML)

- ☐ Highly flexible
- ☐ Moderately flexible
- ☐ Neutral
- ☐ Slightly flexible
- ☐ Not flexible

VII. Challenges and strategies to overcome these challenges

27. What are the primary challenges faced in integrating existing manufacturing technologies with smart manufacturing solutions?

- ☐ Compatibility issues
- ☐ Lack of skilled personnel
- ☐ High initial investment costs
- ☐ Regulatory constraints
- ☐ Others: _____

28. What regulatory or compliance issues do you foresee as potential obstacles to implementing smart manufacturing in India?

- ☐ Lack of clear guidelines
- ☐ Stringent regulatory requirements
- ☐ Compliance costs
- ☐ Others: _____

29. How prepared is the current workforce in India for adopting and utilizing smart manufacturing technologies?

- ☐ Highly skilled
- ☐ Moderately skilled
- ☐ Needs significant training
- ☐ Not skilled at all

30. How can infrastructure challenges for smart manufacturing in India be overcome?

- ☐ Government investment in infrastructure
- ☐ Public-private partnerships
- ☐ Subsidies or incentives for infrastructure development

- ☐ Others: _____

VIII. Economic Impact

31. How aware are you about the potential benefits of smart manufacturing?
    - ☐ Very Aware
    - ☐ Somewhat Aware
    - ☐ Neutral
    - ☐ Not Aware

32. What do you perceive as the potential cost savings from implementing smart manufacturing technologies?
    - ☐ Significant cost savings (more than 20%)
    - ☐ Moderate cost savings (10-20%)
    - ☐ Minimal cost savings (less than 10%)
    - ☐ No cost savings expected
    - ☐ Unsure

33. How do you expect smart manufacturing technologies to impact productivity in your organization or industry?
    - ☐ Significant increase (more than 20%)
    - ☐ Moderate increase (10-20%)
    - ☐ Slight increase (less than 10%)
    - ☐ No impact on productivity
    - ☐ Unsure

34. What is your expectation regarding job creation or workforce impact due to smart manufacturing adoption?
    - ☐ Significant job creation
    - ☐ Some job creation
    - ☐ No impact on jobs
    - ☐ Potential job losses
    - ☐ Unsure

IX. Availability of skilled professionals

35. How would you rate the current skill level of your organization or industry in terms of implementing and managing smart manufacturing systems?
    - ☐ Highly skilled
    - ☐ Moderately skilled
    - ☐ Basic skills with room for improvement
    - ☐ Insufficient skills

- ☐ Unsure

36. What specific skills do you believe are lacking in your organization or industry for effectively implementing smart manufacturing systems?
    - ☐ Data analytics and interpretation
    - ☐ IoT (Internet of Things) integration and management
    - ☐ Automation and robotics expertise
    - ☐ Cybersecurity for smart manufacturing
    - ☐ Others: _____

37. What specific types of training programs would you consider most beneficial for enhancing skills in smart manufacturing technologies?
    - ☐ Technical workshops and hands-on training
    - ☐ Certification courses in relevant technologies
    - ☐ Collaboration with educational institutions for specialized courses
    - ☐ On-the-job training and mentoring programs
    - ☐ Others: _____

38. What skills do you anticipate will be most crucial in the next 5 years for managing and advancing smart manufacturing systems in your organization or industry?
    - ☐ AI and machine learning for predictive maintenance
    - ☐ Advanced robotics and automation
    - ☐ Cloud computing and edge computing
    - ☐ Supply chain integration and optimization
    - ☐ Others: _____

39. How can the government and industry collaborate to improve the availability of skilled professionals in smart manufacturing?
    - ☐ Increased funding for training programs
    - ☐ Developing standardized curricula for smart manufacturing
    - ☐ Establishing more industry-led training centers
    - ☐ Providing incentives for upskilling current workforce

X. Strategies and plan for disaster recovery

40. Does your organization have a documented disaster recovery plan specifically tailored for smart manufacturing systems?
    - ☐ Yes, fully documented and regularly updated
    - ☐ Yes, documented but needs updating
    - ☐ No, not yet developed

41. Which of the following risks are considered in your disaster recovery and business continuity plans?
    - ☐ Natural disasters (e.g., earthquakes, floods)
    - ☐ Cybersecurity incidents (e.g., data breaches, ransomware)
    - ☐ Equipment failures
    - ☐ Supply chain disruptions
    - ☐ Power outages

42. Have you identified and prioritized critical smart manufacturing systems that require immediate recovery in case of a disaster?
    - ☐ Yes, all critical systems are identified and prioritized
    - ☐ Some critical systems are identified, but priorities need reassessment
    - ☐ No, critical systems identification is not completed

43. How often do you conduct testing or simulations of your disaster recovery and business continuity plans?
    - ☐ Quarterly or more frequently
    - ☐ Annually
    - ☐ Every 2-3 years
    - ☐ Plans are not tested or simulated

44. Do you provide regular training to employees on disaster response procedures and their roles in business continuity?
    - ☐ Yes, comprehensive training is provided regularly
    - ☐ Training is provided occasionally
    - ☐ No formal training program in place

45. To what extent are advanced technologies (e.g., AI for predictive analysis, IoT for real-time monitoring) integrated into your disaster recovery and business continuity strategies?
    - ☐ Fully integrated
    - ☐ Partially integrated
    - ☐ Not integrated yet

46. How often do you review and update your disaster recovery and business continuity plans to incorporate lessons learned and emerging risks?
    - ☐ Continuously, with regular updates
    - ☐ Annually
    - ☐ Every 2-3 years
    - ☐ Plans are rarely updated

XI. Road map for future evolution

47. How would you describe the current state of smart manufacturing reference architecture adoption in India?

- ☐ Well-established with widespread adoption
- ☐ Growing, but still in early stages
- ☐ Limited adoption with room for growth
- ☐ Not aware of any existing initiatives

48. Which components do you consider essential for a robust smart manufacturing reference architecture?

- ☐ Interoperability standards
- ☐ Data analytics and AI integration
- ☐ Cybersecurity frameworks
- ☐ Cloud computing infrastructure
- ☐ Edge computing capabilities
- ☐ Others: _____

49. What aspects should be prioritized in the roadmap for the future evolution of smart manufacturing reference architecture in India?

- ☐ Standardization of protocols and interfaces
- ☐ Enhancing scalability and flexibility
- ☐ Incorporating advanced AI and machine learning capabilities
- ☐ Strengthening cybersecurity measures
- ☐ Promoting sustainability and energy efficiency

50. Which emerging technologies do you believe will have the most significant impact on the evolution of smart manufacturing reference architectures in the next decade?

- ☐ 5G and next-gen communication technologies
- ☐ Digital twins and virtual modeling
- ☐ Autonomous robotics and drones
- ☐ Blockchain for supply chain transparency
- ☐ Others: _____

LITD 0023- Study of Reference Architecture for Smart Manufacturing in India

Response for the comments received for Mid Term Report

Response for Comments-1

Comment

When we are including CEN-CENELEC list of standards, we need not to include DIN/DKE standards also on top of it as a) they both are same b) CEN-CENELEC ENs are implemented by all EU member states including Germany (DIN/DKE).

Only one EN 62443 is not captured as part of CEN-CENELEC but shown as part of DIN/DKE list, this can be added in the CEN-CENELEC list and DIN/DKE list can be deleted completely from this report. Also, EN 62443 is also an IEC Standard hence it shall be mentioned as EN IEC 62443.

Response

Thank you for your feedback for the Mid-term report of our BIS R&D project.

Based on your suggestion, as the CEN-CENELEC list already includes the standards from the DIN/DKE list, we will exclude the DIN/DKE standards from the final report.

Additionally as mentioned, EN 62443 will be added to the CEN-CENELEC list, and its notation will be updated to **EN IEC 62443** in the final report.

LITD 0023- Study of Reference Architecture for Smart Manufacturing in India

Response for the comments received for Mid Term Report

Response for Comments-2

Doc Title: Feedback from Users

Comment

1. Timeframes in Q1 are very small considering smart manufacturing solutions started getting implemented in India 5 years back, in some form or the other According to the NASSCOM report on India Industry 4.0 Adoption, it's projected that digital technologies will account for 40% of total manufacturing expenditure by 2025 as compared to 20% of expenditure in 2021.

Response

Thank you for highlighting this. We will revise the timeframe in Q1 to better align with the timeline of smart manufacturing adoption in India extending the timeframe to range from 6 months to 5 years.

Comment

2. Q2 should be multiple choice option since solutions are multi-tech enabled

Response

- Q2 was formatted as multiple-choice in the Word document. However, it seems this functionality was not retained during the PDF conversion.
- We have attached the original Word document where the multiple-choice format is correctly enabled, and we will ensure that it is retained in the PDF version as well.

Doc Title: Questionnaire

Comment-1

Our group is aligned on the ISO definition of Smart Manufacturing. Request the team to please tailor the question to include aspects covered in the agreed definition. TOR of research project includes definition of RA.

Smart Manufacturing: Manufacturing that improves its performance aspects with integrated and intelligent use of processes and resources in cyber, physical, and human spheres to create and deliver products and services, which also collaborates with other domains within enterprises' value chains.

Response

Thank you for your input. We have prepared the questionnaire based on the scope outlined in the ToR. In line with your suggestion, we will include questions to reflect the key aspects of the ISO definition of smart manufacturing.

Comment-2

Questions in the document should be multiple choice as most deal with intersection of data, processes and technologies.

Response

- As mentioned, the questions are already formatted as multiple-choice in the original Word document to address the intersection of data, processes, and technologies effectively.
- We have attached the original Word document for your reference, and we will ensure that it is retained in the PDF version as well.

Doc Title: Mid Term Report

Comment-1

Report should include other relevant standardization bodies like NIST, IEEE, OneM2M and ITU for completeness, especially considering our nation leading new standards with ITU.

Response

- We have already included NIST standards in the report.
- The other relevant standardization bodies, including IEEE, OneM2M, and ITU, have been surveyed and will be incorporated into the final report to provide a more comprehensive perspective.

Comment-2

A tabular representation of features covered by these standards along with their suitability in Indian context as part of the following sections as expected in the original TOR in the final report will help the group a lot.

c) Report on the documents reviewed, clearly listing out the following:

i) Features suitable for adoption and rationale behind the suggestion.

ii) Features not suitable for adoption and rationale behind the suggestion.

iii) Domains which would require input from industry

iv) Summary of the document

Response

- As you mentioned, we will include a tabular representation of the features covered by the standards in the final report.
- Additionally, we will ensure that the report assesses the suitability of these features in the Indian context, as outlined in the original TOR.

Comment-3

An interaction report of the interviews conducted.

Response

As mentioned, an interaction report detailing the interviews conducted will be submitted along with the final report.