ISA DELHI SECTION

TOTAL-2021

TOMORROW'S OPPORTUNITIES WITH TODAY'S AUTOMATION LEADERS

The Automation Virtual Mega Event

3rd September, 2021
and
4th September, 2021
(Friday & Saturday)

An Annual event by International Society for Automation (ISA) Delhi Section

ISA – Setting the standard for Automation

Standards

Certification

Education & Training

Publishing

Conferences & Exhibits

एनटीपीसी
NTPC
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एन टी पी सी लिमिटेड
(भारत सरकार का उद्यम)
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यू. के. भट्टाचार्य
निदेशक (परियोजनाएं)
U. K. BHATTACHARYA
Director (Projects)

Message

I am pleased to know that ISA Delhi Section is organizing a two-day Virtual Conference and Exhibition titled **Tomorrow's Opportunities with Today's Automation Leaders**, 2021. The efforts put by ISA Delhi Section in bringing all stakeholders viz. End Users, Consultants, EPC Companies, Manufacturers, Field Instruments and System vendors, System Integrators and other relevant stakeholders pertaining to Instrumentation and Control on a single platform for Power, Petroleum, Food, Pharma, Chemicals, Fertilizers, Building & Water/Wastewater sector are indeed commendable. Such events aid in sustaining a learning environment helping to perform better.

As we are striving for a Carbon-free economy, innovative ideas for carbon capture, storage and utilization and role of automation in the same is significant. I am glad to note that innovative energy solutions are a point of focus in this conference. Involving young students and academicia and synergizing their zeal and out-of-box thinking with industry is of paramount importance.

Further, it is also heartening to note that with extensive thrust on Make in India, a panel discussion on this topic is on the agenda providing a meeting ground for the various thought leaders to exchange their ideas for creation of a robust eco-system for MII.

I wish the event all success and hope that the momentum will be maintained with renewed vigour in years to come.

(Ujjwal Kanti Bhattacharya)

GAIL (India) Limited

Message

The year 2021 opened up with another disruption due to the COVID-19. In the middle of the uncertainties, many new solutions were crafted within the Energy domain and especially the Oil & Gas industry has been revived beyond expectation. Today India is fast emerging as a global energy powerhouse, where 'clean energy' sector has taken rapid momentum. Also ensuring success to bring affordable energy towards 2030 means more innovative technologies are in the pipeline together with all the stakeholders, especially in the Automation domain.

The platform of ISA Delhi Section TOTAL-2021 is an endeavour to drive the digital technology into Indian Oil & Gas and Power industry in order to create performance headship. With the event being supported by the pioneers of Automation industry from India and abroad, I feel that it will be able to add value for all stakeholders including the end users, suppliers and engineering companies.

We at GAIL have taken several digital initiatives in different spheres of its working such as HR practices, Accounting practices, IT, Cyber security, Gas marketing etc. To name a few such initiatives namely Mobile app for personal claims, Robotic Process Automation in few areas for accounting practices, Paperless Medical Reimbursement for existing executives & also for retired employees, SARAL E-INTEGRATION i.e. GST Web Portal & SAP-ERP System Integration, CGD Business Bill Collection through Bharat Bills Pay System (BBPS), UPI Codes and E-Pay Functionality etc.

We are looking for support from the Indian industry in the form of technologies that can address the core issues of enhancing customer satisfaction, Knowledge sharing and continuous engagement of technology leaders via the Make in India Panel Discussion, I think will be one of the key to success for Infrastructure Automation and Smart Metering, Like in the past many years ISA Delhi section has displayed its commitment to showcase innovative technologies, I am sure that this year also the experts and peers of the industry will be able to discuss the emerging trends and pressing issues. Also considering that the current technology trends of Internet explosion, Industrial Internet of Things, Cloud Computing and Digital Twins shall provide the technical as well as economic benefits as well as a right interface between the automation fraternity and the decision makers in this sector.

I look forward to an enriching two day session where all the participants, delegates, exhibitors and the experts are able to add value in the field of Automation.

With Best Regards

E S Ranganathan
Director (Marketing), GAIL

इंजीनियर्स इंडिया लिमिटेड
(भारत सरकार का उपक्रम)
ENGINEERS INDIA LIMITED
(A Govt. of India Undertaking)
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Regd. Office : Engineers India Bhawan, 1, Bhikaji Cama Place, New Delhi-110066

Message

It gives me immense pleasure to see ISA Delhi Section overcoming the gloom of the pandemic period to come up with a scintillating Online Two Day Technical extravaganza titled **Tomorrow's Opportunities with Today's Automation Leaders**, **2021** meant to bring all major sectors viz. Energy, Process, Manufacturing and Infrastructure together under the ISA umbrella for the benefit of the entire Automation fraternity. The efforts put in by ISA Delhi team in organizing an event of this stature is really praiseworthy. The support provided by End Users, Consultants, EPC Companies, Manufacturers, Field Instruments and System vendors and System Integrators to the cause is indeed commendable. Being so closely related with ISA – Delhi, witnessing the section adopt to new digital methodologies for organizing an event of this scale is like a personal achievement to cherish. I am sure that TOTAL – 2021 will play a very significant role in sustaining the learning edge which is a core tenet of ISA.

Energy sector specifically Oil and Gas sector is witnessing a paradigm shift. Ever stricter environmental regulations is the new normal. Innovative ideas for carbon capture, storage and utilization and role of automation in the same is of paramount importance and TOTAL – 2021 addresses these teething problems in the most comprehensive manner. Digital Refineries is the requirement of the day and the Energy sector needs to exploit the niche digital technologies fully in the upstream, mid-stream and downstream catering to the requirement of the complete sector at large and digitization extends to documentation workflow, operation, maintenance, etc.

The panel discussion planned on Make in India providing a meeting ground for the various thought leaders to exchange their ideas is the priority of the day. The Make in India leading to Atmanirbhar Bharat and manufacturing hub for the world is a nation building mission very close to my heart as on one hand it reenacts EIL's journey and global fame and on the other hand it fulfills ISAD mission of developing domestic industry.

I join others to wish all success and hope to see many such events in times to come.

With Best Regards

Rajiv Gupta
Executive Director (Technical), EIL

एनटीपीसी लिमिटेड
NTPC Limited
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(Formerly National Thermal Power Corporation Ltd.)

कॉर्पोरेट कार्यालय, नोएडा
Corporate Centre NOIDA

Manish Kumar Srivastava
Executive Director (Engineering)

Dt: 03.09.2021

It is most fulfilling to see ISA Delhi Section's transformation and adoption of a fully digital platform in its ever so resounding resolve to serve the Automation fraternity in the form of an Online Two Day Virtual Conference and Exhibition titled **Tomorrow's Opportunities with Today's Automation Leaders, 2021**. The efforts put in by ISA Delhi Section during this pandemic period in creation of a cohesive environment and bringing together all stakeholders related to the field of Instrumentation and Control for a common cause of promoting technology and innovation are highly praiseworthy. TOTAL- 2021 aims to outline the future course of automation by the thought leaders of today which is both challenging and exciting.

Energy sector is undergoing a paradigm shift. Disruptive innovations have made deep inroads in existing business models with focus on Green technologies which are a prime requisite for our sustenance. Data is the key and Intelligent Automation (combining Artificial Intelligence with Automation) is starting to change the way business is done in nearly every sector of the economy. Automation fraternity needs to gear up for the same and it's impending upon ISA and its sections and divisions to support with its ever-expanding knowledge base.

Further, it is also commendable to note that ISA – Delhi section has put a renewed thrust on including more and more technical institutions, faculty and students onboard and it is heartening to note the active participation by Engineering Institutions and students in this technical extravaganza.

Let me join all of you in wishing this mega event, a grand success and hope that ISA – Delhi section will prove to be the torch bearer of change in this digital era across industry segments.

(M.K Srivastava)

Steve Mustard, President (2021-22)
ISA

Message

Thank you to the Delhi Section for the opportunity to address you. As the ISA President, I am committed to ISA's vision to build a better world through automation. Together, we set the standard for automation globally by certifying industry professionals; providing education and training; publishing books and technical articles; hosting conferences and exhibitions for automation professionals; and developing standards for industry.

I hope you enjoy the event, and for those of you who are new to ISA, I hope you will join us in building a better world through automation.

Best wishes for a successful event.

Best regards

Steve Mustard

President, ISA

steve.mustard@au2mation.com

Sujata Tilak, DVP (2021-22)
ISA D14

Message

Congratulations to ISA Delhi Section on organizing TOTAL 2021. Due to the pandemic ISAD had to shift to virtual format, but I am sure participants will get equally good experience and engagement in this format. TOTAL 2021 focuses on many domains and presents tomorrow's opportunities and technologies like IIoT, AI, cyber security, smart logistics, innovative energy solutions and many more. Participation of delegates from end user, OEMs, EPC contractors and consultants will ensure good networking and exchange of ideas. I am happy to see inclusion of student community in the program. I hope all delegates take maximum advantage of the conference and enrich their knowledge and connect with others.

I wish grand success for TOTAL 2021.

Best regards

Sujata Tilak

DVP, ISA D14

Managing Director, Ascent Intellimation Pvt. Ltd.

Sujata.Tilak@aiplindia.com

ISA DELHI SECTION

ASIA PACIFIC DISTRICT 14

Message

Indian market, in this COVID era, despite its complexity and social challenges, is inviting national and international players who have the expertise to take up the Automation technology to the next level. Indian Industry sectors offers abundant opportunities for the qualified, talented, capable engineering professionals and entrepreneurs to bring about that shift in technology to the next level such that great value is created in this time of crises.

The efforts being put by ISA Delhi Section for the past many years on Automation Expositions and Technical Platforms have now become a benchmark for young and experienced professionals alike. Due to the sheer support of ISA Delhi Section's diversified membership base, this time a Virtual Event: TOTAL-2021 was envisaged after a gap of almost two years. The inclusive approach to add other industry domains like Water Waste Water, Building Infrastructure, Manufacturing Industries etc were overwhelmingly supported by all the stake-holders and it became a prime point of interest for a wider base of participants who have already registered for this event.

I believe that automation as a key enabler for increased availability, reliability, safety, stability of the assets of the process plants and infrastructure is now truly note-worthy. And also, that, through such seminars, ISA Delhi Section is striving to facilitate through integrated automation, the realization of world class plants in India with green, clean and lean visualization.

I am sure that through this event our members and other industry participants shall establish national as well as global benchmarks in overall competitiveness.

I extend my heartfelt wishes to all the ISA Delhi Section members and all the participants in this event, to have a very best of time ahead during the event and beyond.

With best Regards

Sushil Kumar
Hon. President, ISA Delhi

ISA DELHI SECTION

ASIA PACIFIC DISTRICT 14

Message

Digital Transformation has become essential in all industries, with the technical and scientific evolutions and developments, to increase productivity through automation of various work flows and analyzing the data for improved and faster decision making.

Innovation strengthened by research & development is important for the growth of the economy in any country. IIoT along with Artificial intelligence and Machine Learning and without compromising cyber-security, being picked up by all sectors in India, is really regarded as the paradigm shift in the world of automation industry and is considered as the most challenging and rewarding.

We believe that any new technology requires good learning and acquisition of knowledge. Keeping the learning zeal for our instrumentation and control professionals in mind and to realize the full potential of new technologies, ISA Delhi section is organizing its flagship mega event - a Two day Conference and Exhibition focused on Automation Technology titled "TOMORROW's OPPORTUNITIES with TODAY's Automation LEADERS (**TOTAL-2021**) on Virtual Platform for the Instrumentation Professionals involved in Energy (Petroleum and Power), Manufacturing (Food and Pharma), Process (Chemical and Fertilizer), Infrastructure (Building and Water/Waste Water) Industry in India.

All the papers for the event has been carefully reviewed and selected by a team of experts from various sectors of industries.

Due to prevailing pandemic of COVID-19, we had to postpone the erstwhile PPAM Meet in 2020, but with the popular demand of our members and a strong conviction of our Executive Committee, this virtual event was envisaged. We are sure that such an important seminar will definitely help all ISA professionals and delegates, working in numerous fields and providing expertise in diverse areas to nearly any technological field in use today, in synchronizing their knowledge with the industry demand.

I really feel honored with the responsibility and delighted to be part of the ISA Delhi Section Team organizing this Conference & exhibition.

I would like to convey my sincere thanks to all ISA members who have worked relentlessly to make this event a grand success.

Looking forward for a happy learning for all of us with an interactive sessions ahead during the event.

With best Regards

Mainak Nandi
Convenor, TOTAL-2021

ISA DELHI SECTION

ASIA PACIFIC DISTRICT 14

Message

The last one and half years of Covid-19 had brought wholesome changes in our lifestyle both at our home and work place. It led to rapid rise and development of virtual avatars continuously upgrading, updating and coming as close to physical as possible. It led to many challenges on one hand and many opportunities on the other. Our team at ISA Delhi while planning TOTAL-2021 took it as an opportunity to connect to wider industry segments in this event without the limitation of geographic constraints.

ISA Delhi has taken a huge responsibility of bringing together the End Users, Engineering Consultants, Process Licensors, EPC Companies, Instrumentation & Control OEMs together for whole gamut of industry segments this time.

The ISA team has worked together to compile a host of technical papers that will surely enrich the delegates with wide coverage and detailed presentations on latest Trends in Industry including IIOT, Digital Twin and Artificial Intelligence along with case studies.

I also hope that the special panel discussion session will trigger new ideas for all the stake holders to come together and deliberate a successful path forward towards self-reliant India.

We have a special Student Section session from young talents which were selected through an Inter College Competition conducted by ISA Delhi.

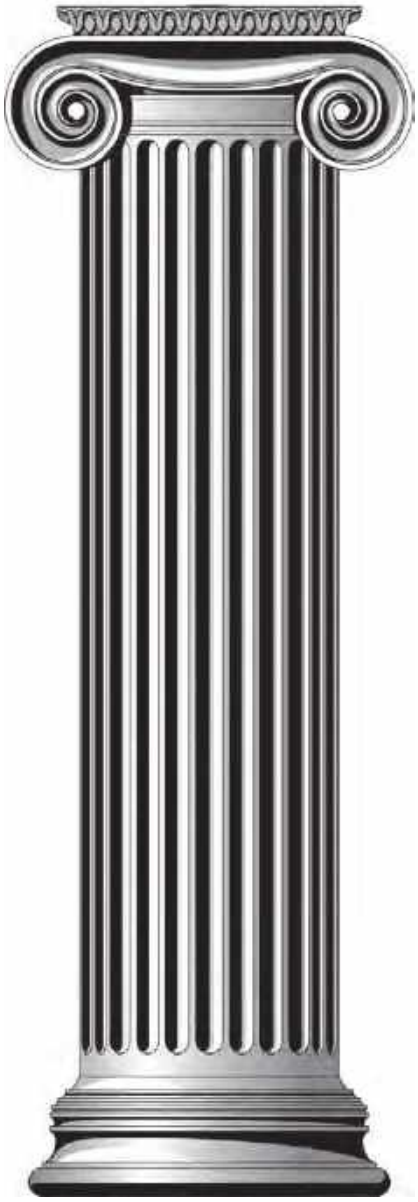
The overwhelming response received overall, has given us a lot of encouragement and it gives me immense pleasure to say that on the basis of the same we are now even more determined to bring many new industry domains under the ambit of ISA Section in the subsequent months.

I am confident that all the attendees will surely enjoy this event even more than the physical one !

With best Regards

Sarvesh Kumar Sharma
Hon. Secretary, ISA Delhi

ISA Delhi Section



The International Society of Automation (ISA)

Founded in 1945, the International Society of Automation (ISA) is a leading, global, nonprofit organization that is setting the standard for automation by helping over 30,000 worldwide members and other professionals to meet, interact and share their knowledge. Based in Research Triangle Park, North Carolina, ISA is organised into 14 districts and hundreds of sections across the world. The South East Asia region is designated as District-14 and within this district, the Delhi Section is an active organization drawing members from the entire spectrum of automation industry across Power, Oil & Gas, Metallurgy, Chemicals & Fertilizers including the Engineering fraternity from Consultants, EPC Contractors, Automation Component Suppliers & Equipment Manufacturers, System Integrators and many other industries.

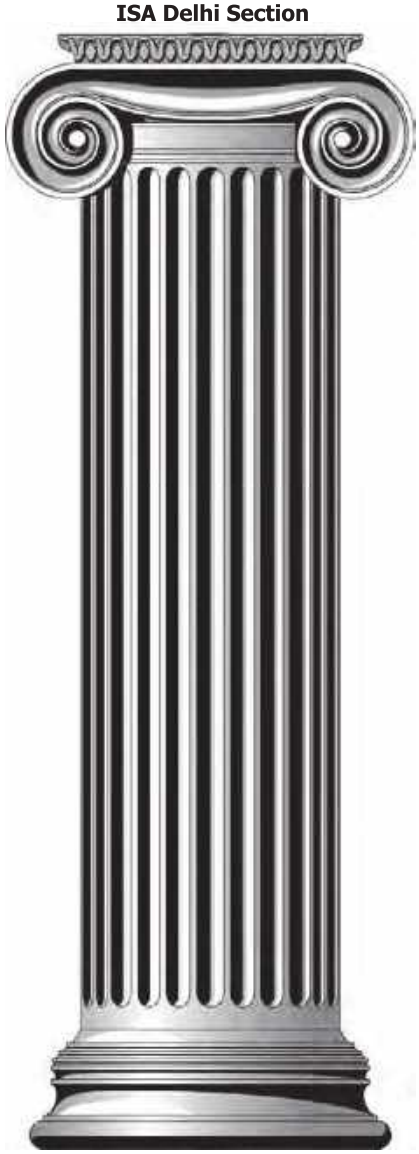
ISA has been involved in promoting emerging technologies across the globe by a variety of ways such as:

- Developing and updating standards for existing & evolving technologies in automation related fields ;
- Publication of Text-books, hand-books, journals, proceedings etc. on a wide array of automation related subjects from primary field sensors to integrated automation and management systems for various kinds of plants & processes;
- Facilitating Interface & interaction with other agencies like IEC, IEEE, EPRI, ASME and others to develop and maintain automation related standards with regular updating, keeping pace with the march of technology in various fields;
- Organising Training, Seminars/Workshops, Webinars and Exhibitions
- Carrying out certification programs for technicians, engineers and senior professionals.
- Recognizing the talented and the dedicated professionals in the field of Automation through various honours and awards
- Enabling Interaction with Student members, formation of student section and annual scholarships, competitions etc. are many interesting student programs of the ISA.

The ISA Delhi Section - ISA(D)

ISA Delhi Section had been formed almost a decade back and has progressed well since then with a membership of more than 350 and growing. ISA Delhi Section had taken many initiatives in the past including organizing two exhibitions ISA (D) EXPO' 05 & '07, PNID' 11,12 & 13, POWAT'09,10,12 &13,PPAM'15,16,17,18&19 a large number of seminars and workshops on emerging technologies. Regular Monthly technical exchanges on diverse topics are organised for the benefit of all members of ISA(D), thereby increasing the knowledgebase & technical capabilities

ISA Delhi Section



of members.

ISA Delhi Section has taken quite a few initiatives in the recent past to better address the need for knowledge sharing among industry specific groups of Automation Engineers. Notably, within the overall ambit of ISA(D), two industry specific interest groups have already been created, one for the Power Industry namely Power Automation Technology group(or POWAT) and one for the Oil & Gas Industry called Petroleum & Natural Gas Industries Automation Domain(PNID). ISA (D) is also encouraging the farmation of a systems integrators forum, so as to share the vast scattered knowledge base resources of systems intergrators community.

ISA Standards

Practical Solutions from Industry Experts

ISA Standards help automation professionals streamline processes and improve industry safety, efficiency, and profitability. Over 150 standards reflect the expertise from over 4,000 industry experts around the world. Since 1949, ISA has been recognized as the expert source for automation and control systems consensus industry standards.

Key Features, Advantages, and Benefits of Standards

Realize a direct return on investment by

- Lowering installation and start-up costs
- Reducing need to maintain large inventories
- Enabling interchangeability of components
- Improving design with less “custom” effort
- Increasing safety

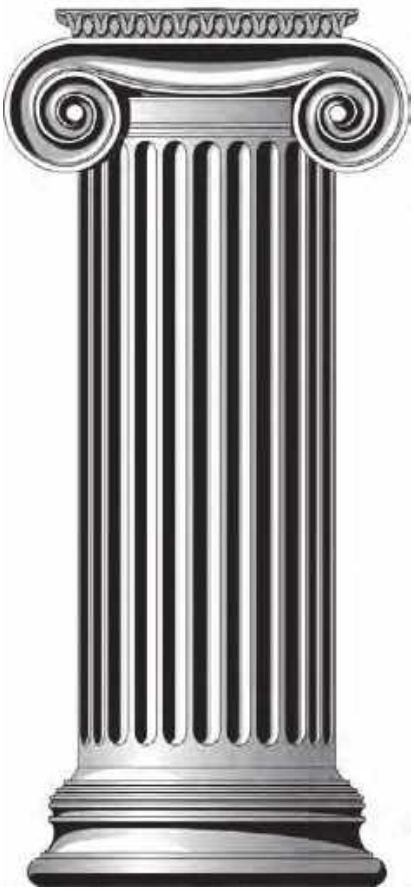
Use of standards in industry

- Improves communication
- Provides practical application of expert knowledge
- Represents years of experience and avoids necessity of starting each project from ground up

Standards help you achieve operational excellence by

- Improving performance
- Lowering maintenance costs
- Reducing downtime
- Enhancing operability
- Saving money

ISA Delhi Section



ISA's Role in Developing Standards

More than 4,000 individuals cooperating with more than 140 committees, subcommittees, working groups and task forces are involved in ISA standards. They're developing standards in areas as diverse as ensuring the safety of electrical equipment used in hazardous locations to cost-savings for interfaces between industrial process control computers and subsystems.

How a Standard Saves Money

ISA's batch control standard illustrates how using a standard cuts costs. Food, pharmaceutical and specialty chemical companies build factories with increasingly sophisticated computer-driven automation. The batch standard ISA developed-ANSI/ISA-88.00.01 - shaves as much as 30 percent off the cost of designing the system and software used in these plants. ANSI/ISA-88.00.01 sets out a blueprint that engineers can use to make portions of the code interchangeable, which is less expensive than designing each piece from the ground up.

The savings extend beyond the facility's design, though. By using the batch standard, companies save as much as 10 to 15 percent off the typical cost of meeting Food and Drug Administration criteria for the reliability of automation equipment.

How a Standard Saves Lives

Other ISA standards focus on safety. ISA has developed standards for the performance requirements of toxic gas detectors, standards to keep electrical equipment from igniting flammable material and standards to ensure safety at nuclear power plants.

And some ISA standards can help an entire industry combine cost savings and safety. The most popular ISA standard is ANSI/ISA-5.1, Instrumentation Symbols and Identification. Developed in 1949 and most recently revised in 2009, these symbols are used in blueprints for everything from power plants to factories. If every contractor on a project knows the standard symbols, there are fewer communication problems that could lead to costly delays or safety problems.

Using Standards to Help Your Business Expand Globally

Your company has a product that's taken the United States by storm; now you want to expand globally. But there is a hitch or, as the engineers might tell you, a "technical barrier to trade.'' Your company's product, or the process by which it's made, doesn't meet international standards. Many ISA standards are also international standards, and our committees strive to stay current with evolving global standards. ISA administers three committees for the International Electro technical Commission (IEC), which is one of the two most widely

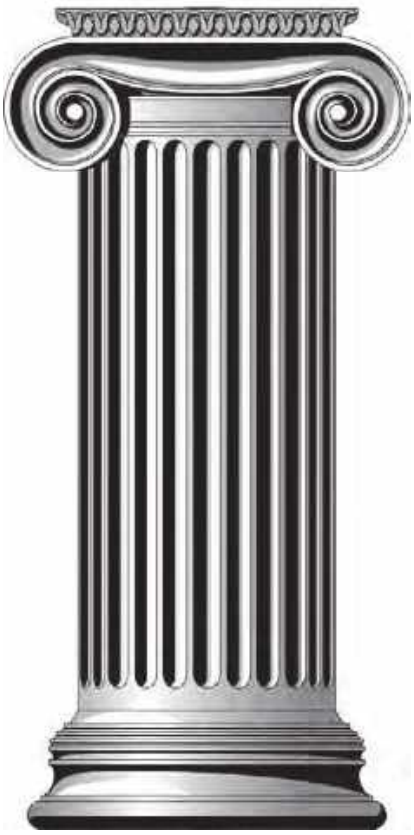
recognized international standards groups, along with International Organization for Standardization (ISO).

How Your Company Can Take Advantage of ISA's Standards

- Buy ISA standards and train your employees to follow it.

- Help set a standard. ISA's committees are eager for help. Both voting and non-voting memberships are available. Voting members must have their employers' approval, in part because attending at least one meeting a year is expected. But we're cutting down on the time demands of committee membership by encouraging members to do a great deal of their work via e-mail. Non-voting members supply input but are not required to attend meetings. Apply online to volunteer.

ISA Delhi Section



Students

Students can come to automation from a variety of backgrounds and academic programs. It is sometimes difficult for you to find programs that concentrate on automation as a career or specialty. This potential variety can create challenges for students like you that are not seen in many areas of studies.

The essence of automation is that it is a multidisciplinary art, not a single discipline. You are required to know a lot about many things to function as an automation professional. Automation studies are rarely centred in one department. Automation students and faculty on a campus could come from any number of engineering areas. That means that published findings could appear in a number of journals and presented at a myriad of scientific conventions. This diversification makes it extremely difficult for students to stay current on the newest findings. It also means that you need to have a very open outlook on what will make you a good automation professional.

The ISA web site helps students more easily stay current on research without attending numerous expensive conventions or wading through non-automation related literature for the useful gems. Also, students can find the conferences they should attend to both gain information and networking possibilities, which can lead to job possibilities.

The ISA web site contains the Automation Body of Knowledge, from the very basics of sensors and controls to the most detailed industrial networking, enterprise integration, cyber security and safety information. When you have digested that Body of Knowledge, you will be ready to be a Certified Automation Professional, and you can find the tutorials and test materials here to help you.

The ISA Mentor Program for Young Professionals and Students

ISA's Mentor Program enables young professional ISA Members and

Student Members to access the wisdom and expertise of seasoned ISA Members, while it offers veteran ISA professionals the chance to share their wisdom and make a difference in someone's career. A mentor can give a young professional guidance in his or her career or help a student determine if automation and control is the right path to follow.

ISA's Mentor Program is an online program, so there are no meetings to attend and there is no travel. ISA Members from all over the world can participate, and the relationship can develop and progress at the convenience of the mentor and protégé.

ISA Members are encouraged to register and participate in the program as mentors. Find out more about becoming a mentor.

ISA's younger Members and Student Members are urged to use this valuable Member benefit. Find out more about getting an ISA Mentor and how to select a mentor.

ISA™

ISA Delhi Section

ISA SECTION LEADERS (2021-2022)

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ISA SECTION LEADERS (2021-2022)

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TOTAL 2021

ISA DELHI SECTION

	PROGRAM DETAILS				
	Date-3rd-4th Sep-2021				
	TOTAL-2021				
	DAY-1	**3-Sep-21**			
	Inaugural Session			**Time**	
1	**Welcome of Participants- Dr. Ashish Manchanda, Treasurer, ISA-D**	**MD, Finder India Pvt Ltd**			
2	**Welcome Address by ISA-D President - Mr. Sushil Kumar**	**DGM, GAIL**		**09:15 AM**	**9:30 AM**
3	**Introduction of Chief Guest and Guests of Honour- Mr. Prasenjit Pal - Sr. Advisor, ISA-D**	**GM, NTPC**		**9:30 AM**	**9:35 AM**
4	**Address By Chief Guest and Guest of Honour** **Expected Dignitaries:** **Ms. Vartika Shukla – C&MD - Engineers India Ltd.** **Mr. Ujjwal Kanti Bhattacharya- Director Project – NTPC** **Mr. E S Ranganathan - Director Marketing - GAIL** **Dr. Prashant Gargava - Member Secretary CPCB** **Mr. V K Raizada - Executive Director - M&I - IOCL** **Mr. Neeraj Agrawal - Executive Director - C&I - NPCIL** **Ms. Alka Tuteja - Executive Director - PEM- BHEL** **Mr. Vivek Malhotra - Chief of Engineering- RIL**			**09:35 AM**	
5	**Note of Gratitude and Way Forward - Mr. Mainak Nandi - Convenor TOTAL-2021**	**CGM, EIL**		**10:25 AM**	
6	**Inauguration of Exhibition (Virtual Stall) and Release of e-Souvenir**			**10:30 AM**	
	Tea Break and Virtual Stall Visit			**10:35 AM**	
	IIoT AND DIGITAL TRANSFORMATION				
	Session -1 :		**Participant**	**10:45 AM**	**12:45 PM**
	Opening Address by Mr. Saikat Bhowal (Sr. GM - Instrumentation)	**Engineers India Limited**			
1	**Simulation and Digital Twin in Process Industry**	SIEMENS LTD.	Roshan Kumar		
2	**Unleashing the Power of Artificial Intelligence at the Industrial Edge**	Schneider Electric	Helenio Gilabert		
3	**IIoT and Digital Technology**	AVEVA	Bharath Bala		
4	**Digital Twins NOA**	Phoenix Contact India Pvt. Ltd.	Suresh Jan		
5	**IIoT in Vibration Monitoring**	Forbes Marshall	Mukesh Vyas		
	Smart Quiz Session				
	Lunch Break and Virtual Stall Visit			**01:00 PM**	**1:30 PM**
	INNOVATIVE ENERGY SOLUTION				
	Session- 2 :			**01:30 PM**	**03:20 PM**
	Opening Address by Mr. S. K. Dutta (GM- PE-C&I)	**NTPC**			
1	**Latest Trend in Stack Emission**	CPCB (Member Secretary)	Prashant Gargava		
2	**Green Hydrogen- for Greening the Grid**	NTPC	Rajan Varshney		
3	**Achieving automated operations and data driven insights from water/wastewater reuse**	Royal Haskoning	Anil Kumar		

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4	**Applicable emission Guidelines and regulation for different types of Industrial stacks**	SICK India Pvt. Ltd.	David Inward Shaji Gopalakrishnan		
5	**Exploring Analytics Potential in Artificial Intelligence**	ASSYSTEM STUP from NMCG Water Sector	Jyoti Dhar		
	Smart Quiz Session				
	Tea Break and Virtual Stall Visit			**03 20 PM**	**03:30PM**
	CYBER SECURITY- SURVEILLANCE IN AUTOMATION				
	Session - 3			**3:30 PM**	**5:30 PM**
	Opening Address by Mr. Jagdish Mitra (CSO and Head of Growth)	**Tech Mahindra**			
1	**Overview of ISA/ IEC standards for security of Industrial Automation and Control Systems (IACS)**	EXIDA Consulting India Pvt. Ltd.	Sudhir Pai		
2	**Industrial Network Security Architecture**	SIEMENS Digital Indusries	Vivek Roy		
3	**Boost your Cyber Resilience for Automotive & Medical IIoT Devices**	TÜV SÜD South Asia Pvt. Ltd.	Sivakumar R		
4	**Making Digitalization Work for you! Approach for Implementation**	Fluor Daniel India Pvt. Ltd.	Amit K Aglave, Pragati Agrawal		
5	**Latest Technology in Testing & Calibration Presenter**	Fluke	Vinod V		
	SPECIAL SESSION - ISA-DELHI- Student Session				
6	**Nursebot: Automating The Healthcare Industry**	Manipal University (Jaipur)	Pranav Sharma, Akshet Patel, Vaspan Motafram		
7	**Auto Attendance System with Face Recognition Using MATLAB**	Bhartiya Vidyapeeth (Delhi)	Aditya Sharma, Hemant Kumar, Vasudev Panth		
	Smart Quiz Session			**5:30 PM**	
	End of Day QUIZ PRIZE ANNOUNCEMENT				
	Delegate Contest Awards				
	Virtual Stall Visit				
	Day-2	**4-Sep-21**			
	AI POTENTIAL IN ANALYTICS				
	Session- 4 :			**09:15 AM**	**11:15 AM**
	Opening Address by Mr. N Vinod (GM-Instrumentation)	**IOCL - Haldia**			
1	**Unlocking the value of industrial AI**	ABB	Anindya Chatterjee		
2	**Emerging Process Automation technologies of Ethernet APL and HART-IP**	FieldComm Group India Society	Paul Sereiko		
3	**Digitizing Process Plants using AI and ML Technologies to Enhance Sustainability**	EMERSON Automation Solutions	Poonam Parmar		

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4	**Comprehensive Early Warning System in Hydro Power Projects located very close to glaciers in Himalayas**	NTPC	Sumit Kumar Haldar, Gunjan Tandon, Praveen Kumar Gupta		
5	**Safe & Optimized Closed Loop Sampling Solution**	Swagelok	Alice Chin		
	Smart Quiz Session				
	Tea Break and Virtual Stall Visit			**11:15 AM**	**11:30 AM**
IT SYNERGY IN INDUSTRIAL AUTOMATION					
	Session-5 :			**11:30 AM**	**1:15 PM**
	Opening Address by Mr. P.K. Gupta (AGM-PE C&I)	**NTPC**			
1	**Ethernet APL for Process Automation**	Pepperl+Fuchs (India) Pvt. Ltd.	Unnikrishnan R		
2	**Significance of 5G on Industrial Automation in the Era of Industry 4.0 and Beyond**	Engineers India Limited	Arupjyoti Saikia		
3	**Operational excellence at Numaligarh Refinery Limited by implementing Web-Based,Database-Driven Digital Logbook and Shift-handover**	HEXAGON	Komal Pawar		
4	**Are We ready to transform your workforce into a digital worker**	ABB	Mangesh Nawarange		
5	**Evolving robust enterprise level in safety instrumented system using IIoT**	SAIPEM India Pvt. Ltd.	M. Ulaganathan		
	Smart Quiz Session				
	Networking Lunch Break and Virtual Stall Visit			**01:15 PM**	**01:45 PM**
TRENDS IN AUTOMATION-INNOMATION					
	Session-6 :			**01:45 PM**	**03:30 PM**
	Opening Address by Mr. Vivek Gupta (Joint Vice President Inst.)	**DCM Sriram Fertilizers**			
1	**Latest Technology adopted in Pharma Industry**	Centrient Pharmaceuticals	Ramesh Walia		
2	**Smart Logistics & Infrastructure**	Bechtel India Pvt. Ltd.	V V V Prakash		
3	**Smart Solutions for Sustainatble Smart Infrastructure**	Fluentgrid Ltd.	Rahul Sharma		
4	**RELAYability – Technology Concepts of Relays in Automation**	FINDER Relay	Andrea Sabbatelli + Ashish Manchanda		
5	**Accurate measurement - an essential element of controlling and improving offshore operations**	Tracerco and EIP	Mohd. Nazir Ahmad Nazrin		
6	**Water Quality Analysers**	HACH	G B Diwakar		
	Smart Quiz Session				

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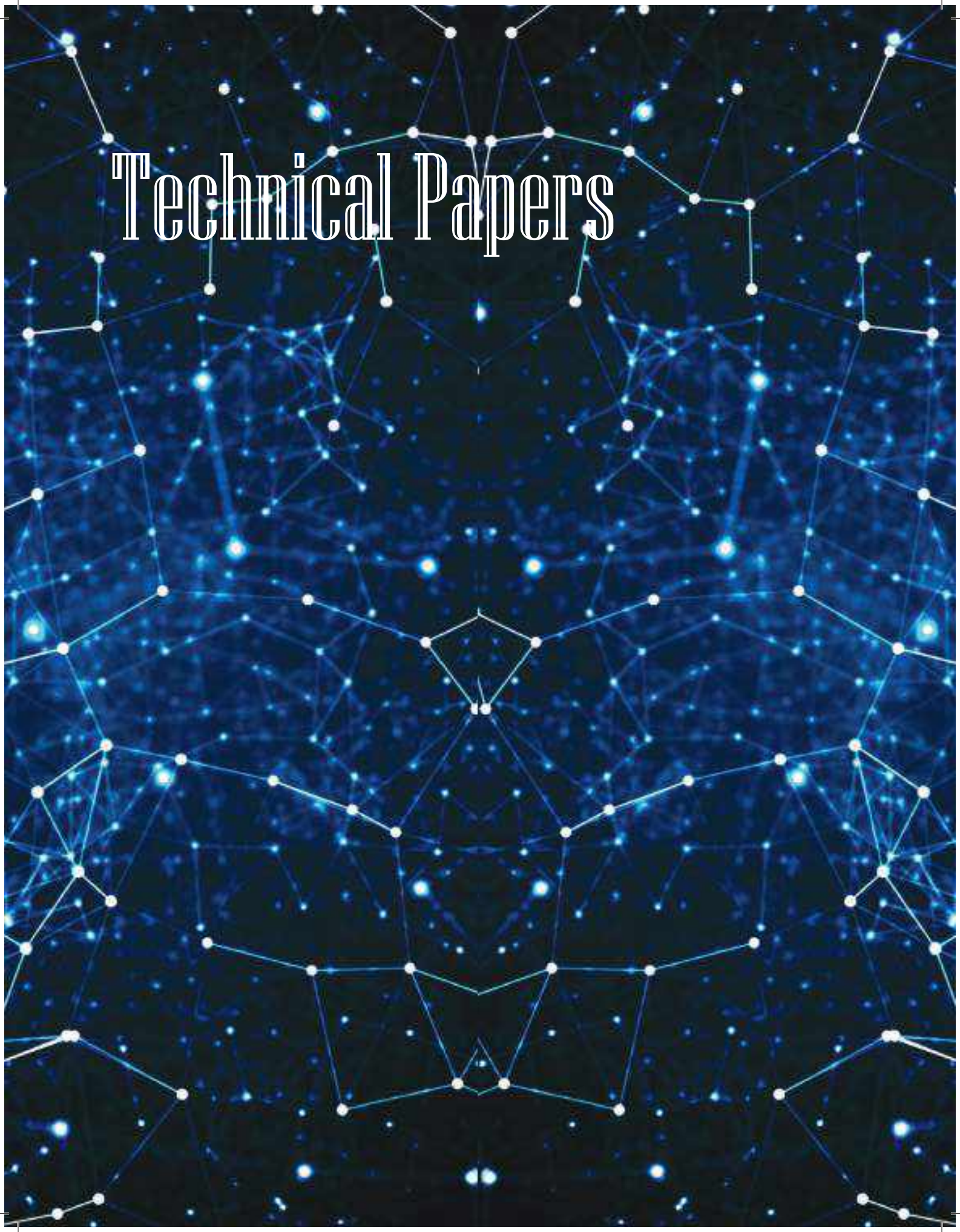
	End of Day QUIZ PRIZE ANNOUNCEMENT			**3:30 PM**	
	Tea Break and Virtual Stall Visit			**03:35 PM**	**03:45 PM**
	SESSION-7: PANEL DISCUSSION				
	TOMORROW's OPPORTUNITIES - A Step towards Indigenisation and Local Manufacturing in Measurement & Automation Segment" **Expected Dignitaries:** **a. Mr. Rajiv Gupta - Executive Director (Technical) - EIL** **b. Mr. M K Srivastava - Executive Director (Engineering) - NTPC** **c. Mr. G Chakraborty - Executive Director - CGD - GAIL** **d. Mr. Sanjay Raizada - CGM - Projects - IOCL** **e. Mr. C. Ananda - Executive Director - BHEL** **f. Mr. Anil Bhatia - Vice President & MD- Emerson Automation Solution** **HOST : Mr. Prasenjit Pal (General Manager - Project - NTPC)** **CO-HOST: Mr. Manish Kumar (DGM- EIL)**	End User : IOCL, GAIL, NTPC Consultant: EIL Heavy Industry & Manufacturing Sector: BHEL, Emerson Automation Solutions		**3:45 PM**	**4:30 PM**
	Honours & Awards			**4:30 PM**	**4:45 PM**
	Student Section Competition Winner Awards				
	Delegate Contest Awards			**4:45 PM**	**4:55 PM**
	Special Felicitation Ceremony - Mr. Sushil Kumar (President ISA Delhi Section) and Mr Mainak Nandi (Convenor TOTAL 2021)			**04:55 PM**	**05:00 PM**
	Special Announcement for ISA Delhi Section Members			**05:00 PM**	
	Vote of Thanks by Secretary - ISA-Delhi -Mr. Sarvesh Kr. Sharma	**Sr. Manager, EIL**			
	NEXT EVENT FOLLOWS				


Technical Papers

Session – 1

Simulation and Digital Twin in Process Industry

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Presented at TOMORROW's OPPORTUNITIES with TODAY's Automation LEADERS (TOTAL-2021); http://www.isadelhi.org

1. Introduction - Simulation and Digital Twin

Digital twins are mostly referred to as the virtual replica of physical assets, be it a product, a machine, a process, or even an entire factory throughout its whole lifecycle. They contain all the information, data and executable models relevant to the management of its real planned or already realized counterpart with simulation as a core technology. During the design and development phase, digital twins and simulations allow best decisions for various design alternatives and optimization of system properties. When in operation, they also help to ensure the best performance, usage and to realize advanced service solutions of an industrial asset. They even support end of life management. This means a digital twin can accompany an industrial product over the whole lifecycle, seamlessly linking together all stages of the value chain.

2. A Digital Twin for Each Industrial Product

Today, digital twins are commonly understood as virtual representations of components, machines, entire production plants, or infrastructures, that leverage operational data to mirror their current state in real- time, helping to manage and control their counter parts in the real world. In the coming years, nearly every industrial or technical product – be it a machine tool, a building, a factory, a production plant, or an electric grid – will come with such a digital twin, enabling detailed simulations and their management over the whole lifecycle. A product's digital twin typically consists of descriptive as well as dynamic models representing different aspects of the system. If the system is rather large or complex – like a manufacturing or power plant – subsystems will have their own digital twins, some of which can be defined by a certain purpose, such as sensing or diagnosis, and therefore only reflect certain aspects of a twin. This also implies that they need standards in order to work together. In some industries like automotive, digital twins already evolve seamlessly along a product's whole lifecycle. They start as twins of a product type with the original design information, engineering models, and testing data. They continue after manufacturing as representations of specific instances of a product using the data collected during operation to support maintenance and service along with other activities. And finally, the digital twin helps to facilitate end of life usage.

Currently, the focus of interest is on the operational phase, allowing for digital twins to be adjusted when the real product gets modified. Another one is using regular simulations to predict the need for maintenance or repair. This allows for better product service, time and cost savings, and an unprecedented flexibility for operation.

A digital twin as a synchronous image of a system in operation enables advanced solutions like extended monitoring, simulation of changes, and simplified control. Since production in nearly all industries is required to be flexible, these digital twins will also support real-time adjustments during operation.

3. Digital Twins Will Form an Ecosystem

For any industrial product to come to life it has to pass through several stages that in many industries – from a digital point of view – are still only loosely interconnected today: from the design and development phase to manufacturing, implementation, operation, end-of-life, and recycling. Digital twins have the potential to build bridges within and between different value chains such as Product Lifecycle Management (PLM) or Supply Chain Management (SCM). This way, they create a whole interconnected ecosystem that will result in cost and time savings, better designs, more efficient and sustainable production and operations, and also new business models. The continuous thread throughout an industrial value chain are digital twins which today as most probably in the future are linked to an IT system such as a cloud platform. They are often complex and hierarchically structured, with many components and subsystems that come with their own digital twins. This way, a digital twin gains value by facilitating to engineer better and more complex systems, e.g., by using a component's digital twin for the development of a larger system and then to create its digital twin. This highlights that digital twins are not tied to their real counterpart they are transferrable goods that can be traded and that enable new applications. By 2030, this should lead to platforms that allow the creation, exchange and trade of digital twins to be used for various industrial applications, in the same way as platforms for Computer Aided Design (CAD) models are a reality today. For this to work seamlessly, it is necessary to develop modular digital twins that function as building blocks for more complex virtual representations, some of which already exist for manufacturing plants today. And because of the specific demands of various industries, we foresee specialized platforms and ecosystems enabling automotive, aerospace or the pharmaceutical industry to be developed.

4. Combination of AI and Simulation

Machine learning, artificial intelligence and simulation can work together to analyze, understand, predict, and optimize complex systems, but they go about it in different ways: ML and AI rely on data, while simulation is typically based on physical models. Both approaches have been developed with little interaction over the last years. Today, design and engineering are mostly dominated by simulation, while operation and service mainly employ ML and AI. Going forward the advantages of each approach will be combined, enabling new solutions.

The strength of each approach compensates the other's weakness: Simulation requires very deep expertise in the application area, high manual effort and is limited to phenomena which are well understood and descriptive in a predictive way. Here AI/ML can help out: They offer flexible approaches for (big/mass) data, which are not well understood yet. On the other hand, there is a high chance for AI/ML to fail if applied to novel areas with limited data, whereas simulation probably will do much better, as long as an area is well understood. Therefore, combining both approaches will be a key enabler for tomorrow's digital twins of complex systems.

5. Digital Twin – Work on virtual platform for automation projects.

When we discuss in perspective to automation project, what are the main challenges in industrial plant commissioning and initial roll out? And what will happen if we cannot handle these challenges properly?

1- Challenges in Engineering and commissioning: Very short time, cost Pressure, lots of uncertainty, not updated documentation due to many on-site modifications.

Leads to: Safety scare, delay, penalty,

2- Challenges in the operation: new automation system, new operation group, unfamiliar plant technology, unfamiliar operation sequence, most importantly safety of the plant.

Leads to: Initial production loss, material loss, damage to man or machinery, safety.

First challenges are in the term of commissioning and initial phases of operation. These are the places where there is maximum uncertainty occurs, and these are places where delays can happen, and safety gets compromises because the plant is starting new. It is exactly at this place we need a solution wherein it is possible to smoothly commission the plant with the help of pretested automation plant, pre-learnt workflows for operating the plant, well defined standard operating procedures and emergency operating procedures.

So, in this digital world, some of the techniques one could adapt in bringing down the uncertainties in the commissioning and bringing safety in the plant is by adapting certain technologies like virtualization and simulation.

The simulation of a plant allows the creation of digital replica of assets for example pumps, valves, air separators and other plant equipment's. So, creating a digital replica of this enable the plant operator to operate it in a way that you may operate in real plant. So, this gives a platform for commissioning engineering to run a sequence of operation and establish the standard operating procedures, emergency operating procedures which can further be fine-tuned during the operation at the subsequent phase.

So, the strategy here is to create the digital replica of physical asset of our plant and then parameterize them with the exact parameter with which the plant equipment is designed with and come up with the strategy of operating those digital assets in a real time environment. Such environment provides the real experience of plant operation and shows all the pitfalls that could happen if the plant is commissioned without correcting these errors. Hence all the pre-test, trial run operation runs exactly as if the real plant with realistic plant operation scenario is created and run digitally. Whole plant commissioning sequence workflow are get created and directed to their actual commission phase. This not only reduces the commissioning phase substantially but also improves the confidence of starting the plant early.

Secondly challenge to talk about is how to train the operator to start plant and operate in the most optimized way for a very first time onwards. So, the efficient way of doing this thing is again use the same tool which was used in the virtual commission and now extend it further to the operation scenarios and get familiarize with the operations steps. so, all the rare occurring scenarios and normal occurring scenario and their familiarization with SOP and EOP can be

easily created, operated and confidence for the operator will go up. That means the plant operators can begin training using virtual platform even before the real plant commissioning is completed. The Operator Training Simulator also makes it possible to provide regular training for plant operators, even in situations that do not occur with the real plant on a regular basis. It also gives new employees an easy and competent entry into their working environment. And further this OTS (operator training system) can be used for workflow optimization and increase the plant operation efficiency.

Key Challenges addressed by Digital Twin:

- Increase our engineering and operational efficiency.
- Raise production quality while cutting costs.
- Shorten commissioning time and enhance plant productivity.
- Ensure reduced risks during actual commissioning.
- Train our plant operators effectively.

Process simulation improves commissioning validation, enhances operating training. Process plants are embracing digitalization to integrate design, engineering, and operations. Punch lists are replaced with evolving technology, bringing more ease to daily operations. In a typical process plant project, approximately 20 percent of the project costs are tied up in commissioning. Ninety percent of that cost is for validating the automation system, and an eye-opening 70 percent devoted to correcting errors. If you didn't complete a validation of your project, you could have an expensive mistake. For example, a motor was burned up because an interlock wasn't verified prior to startup. In the past, the high costs associated with commissioning and error corrections were generally accepted. A commissioning team may include operators, field crew, engineers, plant managers and contractors. Correcting errors, like a burned-up motor, takes these professionals out of service for hours and in serious cases, days. The most efficient way to validate the automation program is to use simulation for a virtual commissioning. Virtual commissioning gives the engineer the capability to test and evaluate processes outside the plant environment. Additionally, process plants are now leveraging simulation in operations. This enables training for inexperienced operators to efficiently handle routine procedures and abnormal situations. In both engineering and operations, simulation reduces costs and time as well as eliminates unprepared operators. The end results include faster time to market and being right the first time.

6. Conclusion

When evaluating the justification of simulation, it is important to calculate the costs of a shutdown or a delayed startup due to commissioning errors. Simulation reduces the number of shutdowns because of its enhanced validation capability. It ensures better operator's involvement and faster reaction times. When operators know what they are doing, ramp up times are shortened, and product changeovers are faster.

More and more, digital twins and simulation will become an essential part of our technical future. With solutions for optimized designs, increased efficiencies, more flexibility, and higher production, application of digital Twin are easy to apply. Digital twins and the applications enable building blocks of our future process plants.

SIEMENS

Process Automation Profile

Digital Industries

Roshan Kumar

Business Development Professional, Process Automation, Siemens Ltd.

Mr. Roshan Kumar is a part of central Team working at Siemens India Process Automation Headquarter in Mumbai. He is responsible for business development of DCS, high-end Automation system and process simulation which offers complete range of products for automation systems from PLCs, DCS, Safety systems, etc.

He has an experience of more than a decade in the field of Automation. He has worked in various functions including engineering, pre-sales, product Management and business development etc.

By 2030, the continued development of digital twins should lead to full-scale intelligent digital process plants being the new standard. **– Roshan Kumar**

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About Siemens Ltd.

Siemens Limited focuses on the areas of electrification, automation and digitalization. It is one of the leading producers of technologies for combined cycle turbines for power generation; power transmission and distribution solutions; infrastructure solutions for Smart Cities and transportation; automation and software solutions for industry, and also supplier of healthcare equipments. Siemens Ltd. has 22 factories located across India and a nation-wide sales and service network. Siemens Limited, in which Siemens AG holds 75% of the capital, is the flagship listed company of Siemens AG in India. As of September 30, 2015, Siemens Limited had Revenue of INR 106,728 million and 10,168 employees.

Setting the Standard for Automation™

Unleashing the Power of Artificial Intelligence at the Industrial Edge

Helenio Gilabert
Senior Director Business Transformation
Schneider Electric

Our challenges have changed

- Remote operation requirements and cybersecurity
- Knowledge drain and knowledge transfer
- Access to experienced operators
- Market volatility
- Environmental impact and sustainability
- Digital transformation acceleration

Life Is On Schneider Electric

Innovation is not just about technology

- From ownership to subscribership
- Vibrant ecosystem of startups
- Hardware lifecycle expectations are changing
- Agility in (co-)innovation
- IT/OT convergence

Life Is On Schneider Electric

AI – From specialized to mainstream

- Emerging edge controllers have enough power to run AI
- Cloud to Edge platforms allow for deployment (and management) at scale
- Availability of open frameworks allow anyone to create/interact with Machine Learning models
- Has the potential to drastically transform your operations

Life Is On Schneider Electric

Benefits of AI in industrial applications

- Deploy an “engineer in a box” to valuable assets
  - Detect and alarm on abnormal operating events
  - Capture and automate expertise from operators using machine learning
- Adopt flexible optimization strategies
  - Throughput
  - Asset lifetime
  - Energy efficiency and environmental impact

Life Is On Schneider Electric

Why AI @ the Edge

- Integration with legacy infrastructure
- “Off the shelf” hardware
- Edge execution to optimize:
  - Latency susceptibility
  - Connectivity availability
  - Bandwidth and storage costs
  - Application maintenance

Life Is On Schneider Electric

The new services economy

- Cost effective subscription models (OPEX)
- Risk shifts to vendor
- Requires continuous vendor engagement (Customer Success Management)
- Lowers complexity
- Implementation flexibility
- Accelerated (co-)innovation

Life Is On Schneider Electric

A real-life example…

Online portal for interaction with ML models

Integration with existing control system

Industrial Controller

IoT Controller

Industrial HMI

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… with great results

EcoStruxure Plant
Innovation At Every Level

Apps, Analytics & Services	 **EcoStruxure** Autonomous Production Advisor
Edge Control	 **SCADAPack Realift, Gateway 101 and Geo SCADA Expert**
Connected Products	 **Altivar** Drives

34% reduction
in energy consumption

13% increase
in barrels of oil produced

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IIoT and Digital Technology

Author: Bharath Bala, Pre Sales Consultant, Aveva

Topics

- Introduction
- IIoT
- Use Cases
- IIoT & Digital Twin
- IIoT Value Proposition
- IIoT Challenges
- Summary

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Presented at TOMORROW's OPPORTUNITIES with TODAY's Automation LEADERS (TOTAL-2021); http://www.isadelhi.org

Introduction

Big data is a term that describes large volume of data, but it's not the amount of data that matters but what organizations do with the data that really matters. The advances in the technology enables stream data into businesses at very high speeds, and this becomes the driver for the opportunities.

Why do we need more data? Because they help achieve the following:

But Data collection has been done using the traditional techniques over the last 40 years and has always been at variance with the customer needs:

And to add to the above the current Market environment is experiencing:

- Rising costs of managing automation systems
- Increasing market/customer demands

- Tightening Environment, Quality, Safety Regulations
- Competitive and Economic Pressures

In the face of these challenges the newer technology trends help with the Business Imperatives of Enterprise visibility, Real-time decision support, Benchmarking, Anomalies detection and Optimization. One such trend is IIOT or Industrial Internet of Things.

IIoT:

The Industrial internet of things (IIoT) refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management. This connectivity allows for data collection, exchange, and analysis, potentially facilitating improvements in productivity and efficiency as well as other economic benefits.

- IoT (Internet of Things) and IIoT are the same in principle, but there are differences between their general usages and the technology/protocols used therein.
    - IoT is mainly used for consumer usage (connected vehicles, home automation, wearable technology, connected health etc.) and is B2C (business-to-consumer) centric.
    - IIoT is used for industrial purpose such as manufacturing, supervision, supply chain and is B2B (business-to-business) centric.

Areas in which IIoT data can typically generate value include:

- Asset Performance Management
- Improved Planning & Productivity
- Data-Driven Communication Between Stakeholders

Use Cases:

Use Case 1: Geographical Asset Distribution
Operational Challenges:

- Delayed decision making and response times due to lack of seamless visibility of operations and assets across a geographically distributed, high latency WAN telemetry network.
- High cost of project engineering and deployment due to integration and maintenance of multiple 3rd party communications software packages.
- Elevated Cybersecurity risks associated with access to remote field devices and assets not under direct control of the IT network.

Costs:

- Manpower
- Communication charges
- Process disruption

Implications:

- Service outages or failure to meet contract obligations.
- Delayed response to and resolution of HSE events.
- Loss/Lack of visibility and control of current operations
- Loss of field data required for billing
- Reduced returns from operations
- Cyber security risks

Use Case 2: Expanding Visibility:

Operational Challenges:

- Lack of information due to high cost of traditional end point networking for an HMI interface.
- Technocrats visiting sites to collect data and fix issues.
- Lack of information, delayed

reporting Costs:

- Operational Efficiency
- Manpower
- Delayed response time

Implications:

- Decision errors due to lack of situational awareness
- Delayed response to and resolution of health, safety and environment events.
- Complex IT management and associated worker training requirements

Use Case 3: Collect data for Analytics, ML, Digital Twin:

Operational Challenges:

- Connect and incorporate existing infrastructure
- Installation of new communication infrastructure
- Elevated Cybersecurity risks associated with access to remote field devices and assets not under direct control of the IT network.
- High data availability (Store & Forward)
- Guarantee openness of the solutions
- Cost-effective IT solutions

Cost
s:

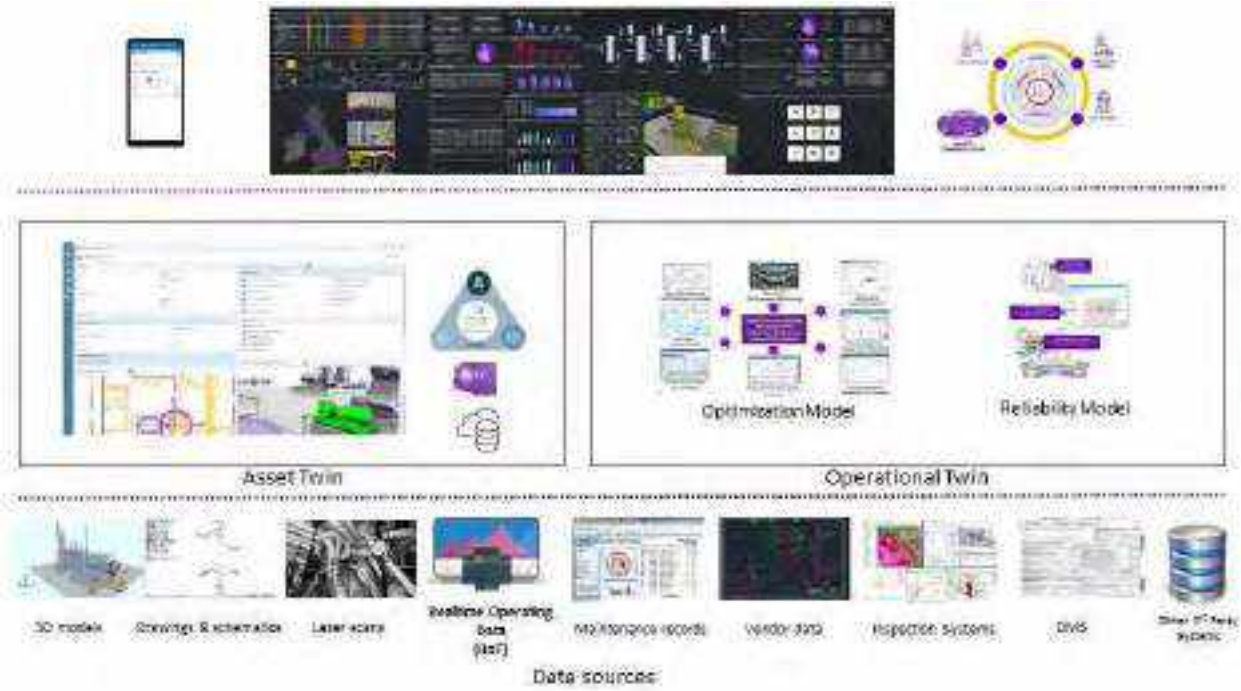
- High cost of project engineering and deployment due custom solutions
- Modification of existing systems
- Communication infrastructure

Implications:

- High TCO
- No standardization
- New investments

IIOT & Digital Twin:

A digital twin is a virtual representation that serves as the real-time digital counterpart of a physical object or process. The digital twin concept consists of three distinct parts: the physical product, the digital equivalent, and connections between these two entities. The connections refer to the data that flows from the physical product to the digital product and information that is available from the digital equivalent back to the physical environment. It is this connection of Data that is enabled with the help of IIOT.



Asset Twin:

An example of a digital twins that uses 3D modeling to create digital companions for the physical objects. It can be used to view the status of the actual physical object, which provides a way to project physical objects into the digital world. For example, when sensors collect data from a connected device, the sensor data can be used to update a "digital twin" copy of the device's state in real time. The term "device shadow" is also used for the concept of a digital twin. The digital twin is meant to be an up-to- date and accurate copy of the physical object's properties and states, including shape, position, gesture, status and motion.

Operational Twin:

An example of a digital twin also can be used for monitoring, diagnostics and prognostics to optimize asset performance and utilization. In this field, sensory data can be combined with historical data, human expertise and fleet and simulation learning to improve the outcome of prognostics. Therefore, complex prognostics and intelligent maintenance system platforms can use digital twins in finding the root cause of issues and improve productivity.

IIoT provides the sensory data to enable Process Optimization that employs first-principle simulation techniques in the following:

- Real-time process data and rigorous simulation models, to generate highly accurate & validated process and equipment performance information
- Real-time process data and economic data to determine set points that guarantee maximum operating profit while satisfying all operating, safety and equipment related constraints.

IIOT Value:

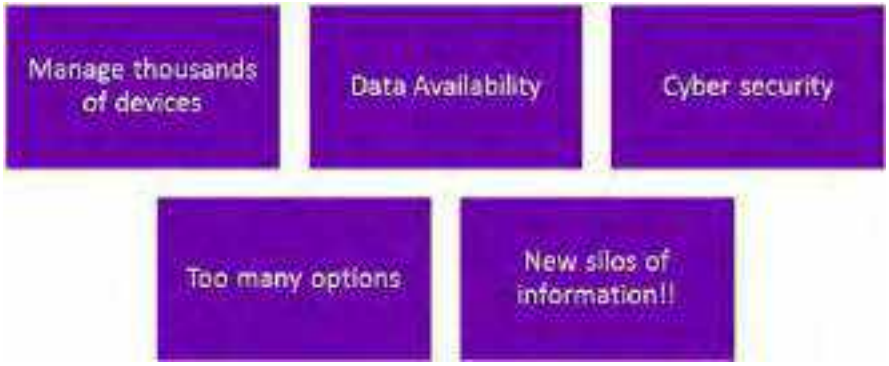
Below is the snapshot of the main personas (buyers and users) involved in typical projects, their Responsibilities and Challenges, the Value, and the capabilities of the IIOT solution, and the business outcomes that are achieved through the capabilities.

In this paper, three different departments are being considered:

- Operations/Maintenance: The end user of the solutions
  - From the Head or Manager of the Operations and/or Maintenance departments, to the Senior Process Engineers or even Instrumentation Engineer because they are involved in the day-to-day projects.
- The IT department is responsible for the IT solutions, or OT. It is usually the same, but some companies have dedicated departments to manage the “Industrial IT” (OT=Operations Technologies)
- R&D (responsible to investigate new uses of the technology in their business) and Technical Services/SI (responsible to develop/deliver/maintain solutions)

-

IIOT Challenges:



- The challenge of costs of managing thousands of devices.
- Data availability: What happens if no data is sent for an extended time period?
- Cybersecurity challenges
- Too many options (networks, platforms, vendors, new players, new protocols, …) and the
  customers have difficulties to find the right choice.
- Some networks don't have local availability, and others will require the installation of communication infrastructure.
- On the contrary, IIoT is creating new silos of information because there are different vendors, new players, startups, ….

Summary:

The future of IIoT is tightly coupled with Industry 4.0. which, essentially, the fourth Industrial Revolution.
Industry 4.0 is based on the use of connected electronic devices -- particularly, IIoT devices. Going forward, IIoT devices will play a major role in digital transformations, especially as organizations attempt to digitize their production lines and supply chains. Additionally, big data analytics will evolve to incorporate IIoT data. This will make it possible for organizations to detect changing conditions in real time and respond accordingly.

Although IIoT devices have been around for several years, real-world adoption is still in its infancy. This is sure to change as 5G becomes increasingly prevalent and more and more organizations begin to realize what IIoT can do for them.

References:

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2. https://en.wikipedia.org/wiki/Digital_twin
3. White Paper - Challenges, Opportunities, and Strategies for Integrating IIoT Sensors with Industrial Data Ecosystems – OSIsoft
4. ELEVATE 2021 IIOT & Edge Presentation – Aveva.

Technical Paper Digital -Twin & NOA

Suresh Jan Head – Process Industry – Projects

Content

1. Idea of NOA
2. Architecture/ Technology Scheme
3. Digital Twin solution

1. Idea of NOA

NOA stands for NAMUR Open Architecture and it is a concept to bring modern technologies around "Industry 4.0" into older process plants.

The NAMUR is a user organization of mainly German chemical companies like BASF or Bayer. It was founded after second world war. Meanwhile they have over 140 members and became worldwide important. In over 40 workgroups, technical recommendations for process and chemical industry are elaborated. The NAMUR publishes periodically "NE" s which
stands for "NAMUR Empfehlung" (NAMUR Recommendation). An example is one of the first NE, which recommend using a 4…20mA instead of 0…20mA to detect sensor failures.

It is a fact that process plants have a long lifetime compared to a car production plant e.g. This makes it harder to bring new technologies like the Profinet Fieldbus into the plant. The NAMUR searched for ideas to bring new technologies into the older plants and founded the NOA concept.

Another fact is that a lot of unused data is in a process plant. The sensors became more and more complex and the have a lot of information inside which are not transferred to the control system because the connection is still a 4…20mA signal. This additional data could help to
improve the plant by doing asset management, predictive maintenance or artificial intelligence.

A typical architecture of a plant in general is the "Automation Pyramid" with an ERP system in the top and a sensor/actor layer in the bottom, in between control system layers.

A main requirement of almost all plant operators is not to change the main control system.

This brings up the idea of a "Side Channel" to place smaller additional controllers for new additional functionalities. Another main requirement of the plant operators was that these new plant components must be safe against unauthorized access from outside which add the topic that this side channel has to be OPEN and SECURE.

Figure 1: NOA Pyramid

NOA concept is mainly for older plants were new technologies are not integrated and with the help of New technology components it can be done.

Newer process plants, which already have HART interfaces on each input module or with integrated predictive maintenance functionalities e.g. are not in focus of this concept!

2. Architecture/ Technology Scheme

The target of this NOA concept is to place additional devices in the NOA side channel, which allows to collect data from the plant without touching the existing control system. These devices must be secure from "IT" view.

Examples:

- A controller must have a protected user interface with user and password. Other (Data) Interfaces must have a protection as well like OPC UA it has.
- The security on sensor lever can be: HART communication with READ ONLY functionality, a signal splitter on 4…20mA or current transducer for energy measurement or an additional sensor which is not connected to the main control system.
- To use existing fieldbuses requires a careful planning and a security concept for the specific fieldbus.
- The collected data has to be transferred to a target (Internal Cloud, Internet Cloud or DCS System e.g.) on a save and protected way. This can be made with a VPN tunnel by an mGuard Security Router.

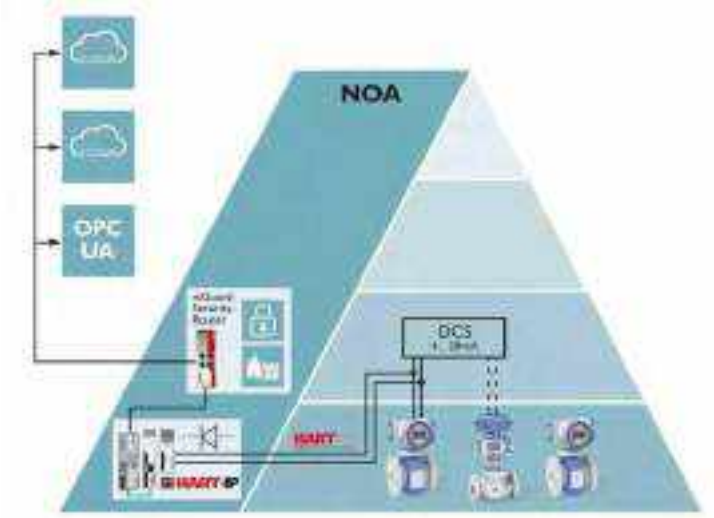


Figure 2: NOA with HART connection to existing process plant sensors

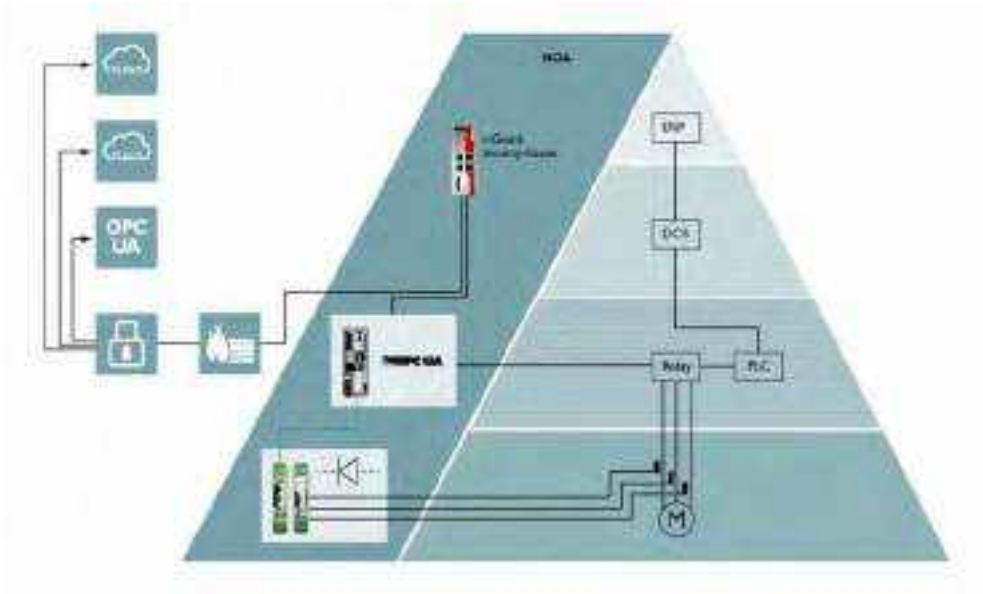


Figure 3: NOA with Motormanager EMM 3-XXX and current transducer

3. Whether the new NOA concept or a traditional data collector in a plant Phoenix Contact has a good and very large portfolio for this task. Beginning with 4…20mA signal splitter of the MCR/ MACX family, the modular HART Gateway or the Motor manager Modules for energy measurement and many more. A conversation with the customer helps to find the right devices fitting to the customers' needs and requirements.

Key device of this solution is the PLCnext controller. It has…

- Security functionalities (Restricted access with user + password, HTTPS…)
- OPC UA Interface for a protected communication with higher systems
- Open Source Platform for High Language Data Applications and Cloud connections
- Docker® Functionality, which makes it easy to install applications like IIOT Server
- Access to almost all Fieldbuses by using the Axioline Family
- Complete IO Modul Portfolio
- ATEX Zone 2 Approbation
- Attractive Price

3.1 Digital Twin

By using the HART GW, the AXC F 2152 with an 8GB PLCnext SD Card and an IIOT Server of the company. We can offer a smart solution for collecting all unused HART data of connected sensors.

The IIOT Server has a pool of 1800 description files of HART sensors (eDD, FDI) integrated, which allows the access of all HART parameters of the connected sensors instead of the standard commandos of a solution without this IIOT Server. The factor is 3…10 times more data from each sensor. Depends on the complexity of the sensor.

During the installation is an internet connection necessary, after the setup and download of the data package the internet connection can be disconnected, what a requirement of the most customers is the interface to the customer is OPC UA.

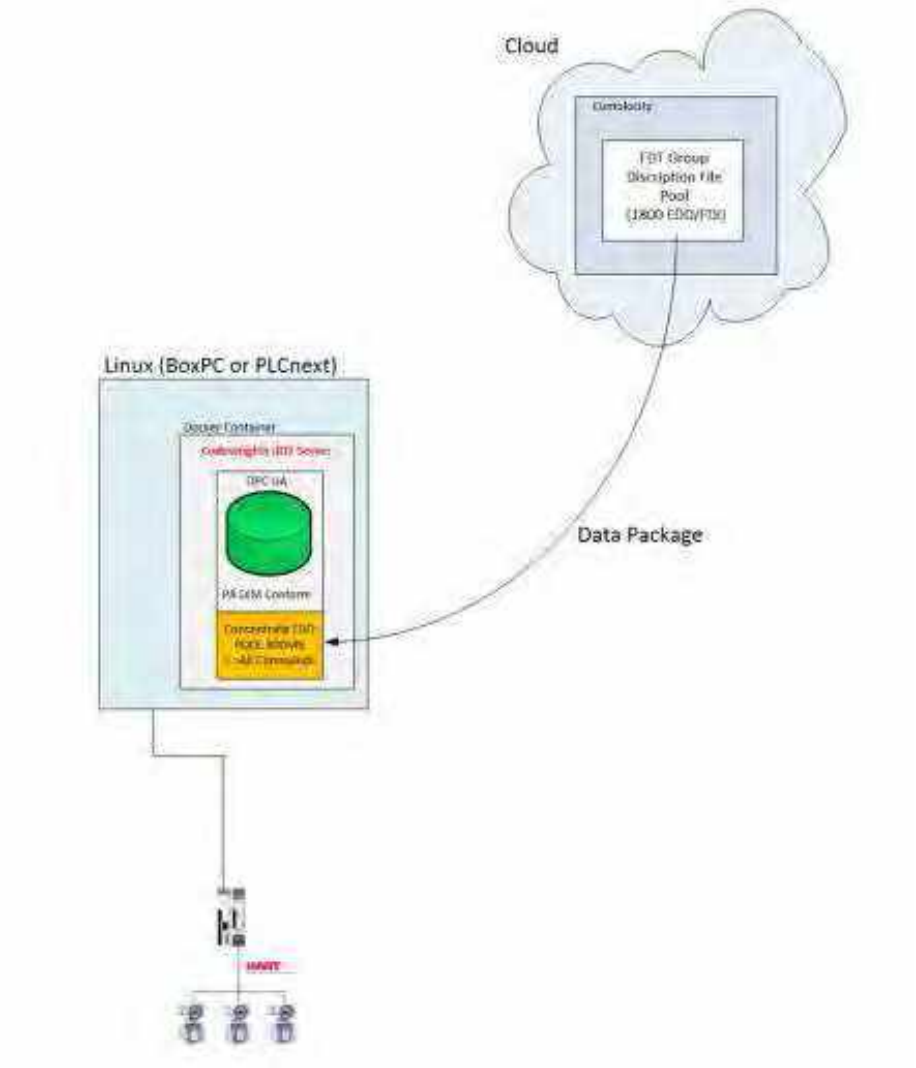
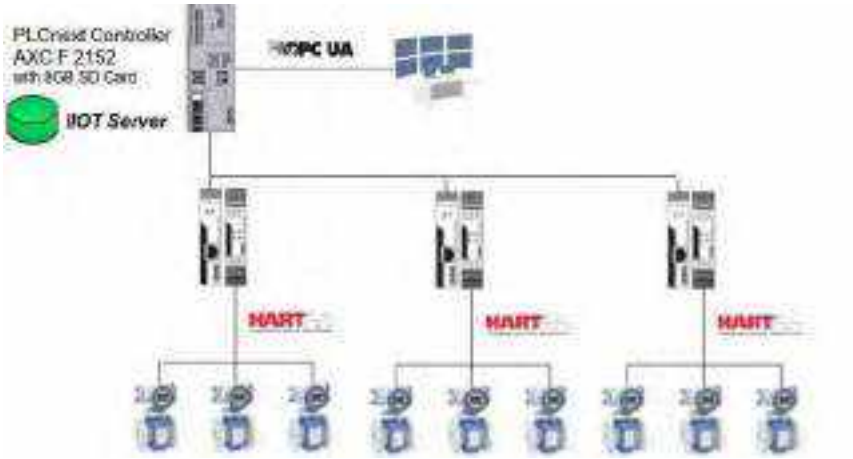


Figure 4: IIOT Server: Description file pool



One controller OPC UA integrated can handle up to five full extended HART Gateways with 40 connected sensors = 200 sensors in sum.

- This solution needs no application programming. The IIOT Server will be installed by using the Docker functionality. For the installation an application engineer is necessary.
- A field engineer has to install the physical HART connections. Several terminals are useable.
- **In the most cases a loop check is necessary after the installation**.

Session – 2

Green Hydrogen- for Greening the Grid

INTEGRATING RENEWABLES INTO GRID SUSTAINABLY

Paper in ISA 3-4 September 2021

Rajan Varshney , NTPC
CC- DGM (Engineering-TF)

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Presented at **TOMORROW's OPPORTUNITIES with TODAY's Automation LEADERS (TOTAL-2021)**; http://www.isadelhi.org

INDEX

Abstract

This paper gives about Importance of Hydrogen economy in today's context for Combating Climate change and applications of Hydrogen in efficient storage technology for renewable integration with grid stability in an environment friendly manner. Also there are a host of opportunities for Green Hydrogen e.g. cleaner & efficient fuel option for long distance transport, Cement and other industries. It can also help in better management of Industrial and Agro wastes & generation of Bioethanol, Green Ammonia, Green Steel etc.

Hydrogen today though is widely used but is mostly either brown or Gray. It is produced from of Gasification of coal or Steam methane reforming of natural gas. Both these processes are not carbon-friendly. A purportedly cleaner option is known as blue hydrogen, where the gas is produced by steam methane reformation but the emissions are curtailed using carbon capture and storage. This process could roughly halve the amount of carbon produced, but it's still far from emissions-free.

Green hydrogen, in contrast, could almost eliminate emissions by using renewable energy — increasingly cheaper and quite abundant and often generated at less-than-ideal times. But due to its higher cost, hardly 4% of the hydrogen used is Green Hydrogen.

Hydrogen can be produced from Electrolysis of water and also from Biomass and even from Plastics. Hydrogen can also be used to produce electricity. Presently. Fuel Cells are supplying 24x7 reliable RTC Base-load Power for Data Servers of Google, Yahoo etc. across various Geographies.

Despite all the challenges that present Covid times, Hydrogen Projects are coming up at a staggering pace. More and more countries are announcing their ambitious clean-hydrogen strategies to help them de-carbonize transport, heating and heavy industry. Many of these projects are gigawatt-scale, with the hope that their immense size will quickly bring down the cost of green hydrogen through economies of scale — in the same way that the prices of wind and solar power have fallen exponentially over the past decade.

This paper also covers various methods and technologies of H2 production being used, deployed or researched and How H2 can be used in Replacing Fossil fuels in Generating Energy. In addition this paper also delves about suggestive business models like Microgrids in todays' environment where Consumer has become Prosumer and in the scenario of bidirectional flow of Power.

The IOT based distribution control and optimization algorithms and optimizing controls need to be adopted for integrating vehicles, Batteries, PVs, Wind Turbines, Hydrogen etc. into the Microgrids efficiently. Long distance Transmission and Big Centralized power projects can no more be assured of recovering their fixed costs as consumer cannot be burdened with high inefficiencies in the system at various levels. Now it is

no more supply based model rather electricity has to be only as per demand and quality required by consumer.

Policy support and regulatory framework required for directing investments for sustainable and reliable grid by deploying surplus power to produce Hydrogen and creating Demand for the Hydrogen produced by mandating industry for using green hydrogen has been brought out. Supporting the development of required ecosystem and skills can generate lot of jobs and put economy on a upward trajectory resulting in a win-win situation for all the stakeholders.

Keywords- Electrolyser, RTC, Green Ammonia, Green Steel, Microgrid

Introduction

As the severe consequences of climate change are being witnessed with increasing frequency and magnitude, decarbonization efforts world over are being accorded top priority. Recent August, 2021: IPCC report has pointed out that we will cross the 1.5° C warming target by 2040 itself and we need to catalyse more momentum towards reducing GHG. It is increasingly being recognized that hydrogen has an important role to play in the Low carbon energy transition required for survival of mankind. Use of Low carbon Hydrogen (like by Proton Energy), Green Hydrogen generated using clean energy sources and Carbon negative hydrogen produced from biomass is gaining priority.

Hydrogen can de-carbonize electricity generation, all forms of Transport, Heating/cooling eand also the hard to abate industrial sectors like Steel, Cement, Fertilisers, Oil Refining etc.

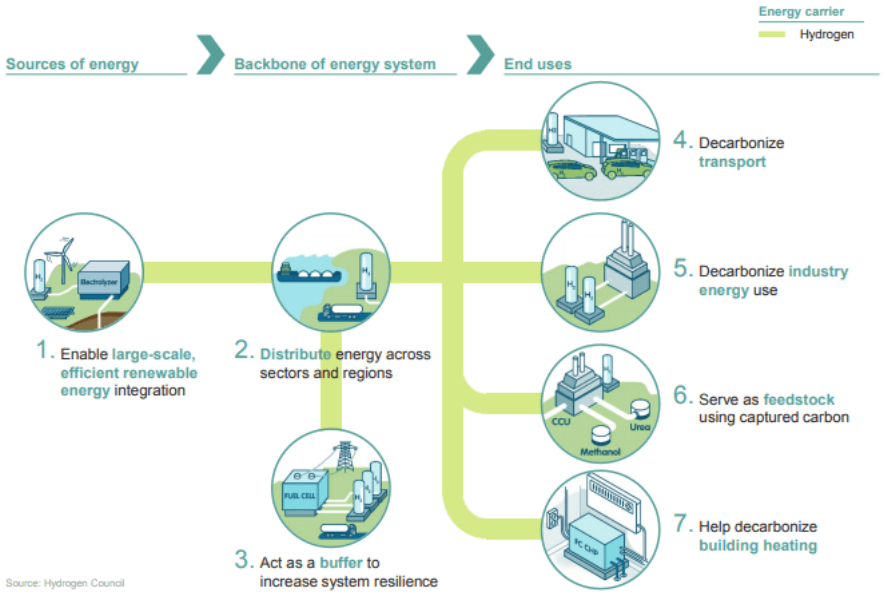
India's total power generation is 385GW and peak load has touched 200.57GW recently on 7th July 2021. Total renewable generation capacity (except Large Hydro) is 100GW. Planned RE capacity is 175GW by 2022 and 450 GW by 2030. So, each year much more renewable is being added and thermal addition is very little year on year. Renewable generation through solar, wind etc. is intermittent and does not match with the load requirements during the day posing duck-back curve challenges, causing lot of partial loading or shutting down of RE.

Approach is to convert excess power to Hydrogen and use it as and when required in whatever quantity at whichever location for various applications.

Excess power can be transmitted as Hydrogen to high demand areas at the time/seasons required without additional power generation or transmission infrastructure. This approach helps grid balancing in the scenario of increasing renewable energy generation. It also combats the climate change.

As we have already seen the effect of Moore's law on ICs and Swanson's law on PVs, in view of increasing technological developments and corresponding cost reductions, for taking advantage of scaling, increasing conversion efficiencies and other technological developments, it is imperative H2 area to can become self-reliant and competitive.

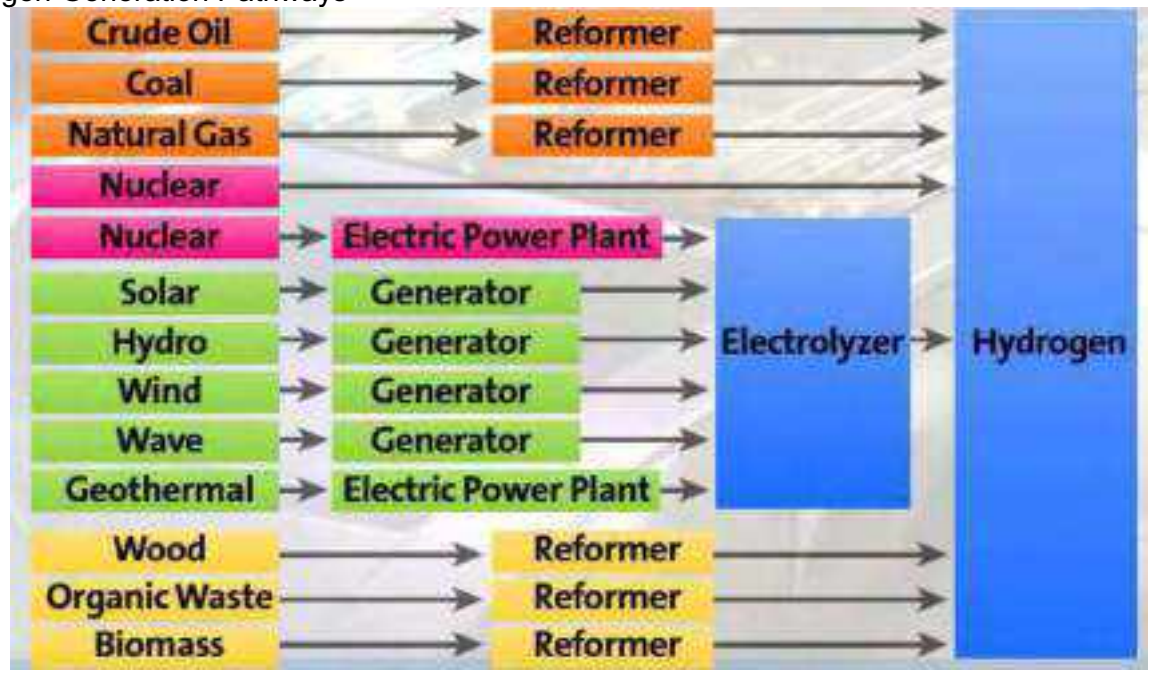
Thus, the proposed approach resolves various issues by storing excess power in a green manner and allows its usage as and when required, segregating the quantity, conversion medium and storage sizing and location of use/ application.



Main industries consuming hydrogen

- 93% Ammonia production and oil refineries
- 6% Float glass, steel and semi-conductors
- 1% Power plants, oil hydrogenation and mobility

Hydrogen Generation Pathways



Waste to Hydrogen (Carbon -ve H2)

- Benefits : Carbon –ve H2 as well as Waste Treatment and no landfills and no CH4 emission (which is 25 times more potent GHG than CO2)
- All waste including medical waste, MSW, plastics, agricultural residue, wastewater sludge To H2, with a net –ve carbon footprint.
- By deploying waste-to-H2 plants near H2-fueling stations and fleets of fuel-cell vehicles, as well as onsite hydrogen power generators: waste generators and processors alike can advance their industries while greatly increasing sustainability.
- --Decentralised Waste treatment for H2 Production may be in lots of 50- 300 T, Otherwise wet waste generates lot of CH4 etc which gets wasted and causes GHG emission and Decreases economic value of waste with time. Also expenses, GHG emission and pollution in Transport can be avoided

Companies in the fray:

- Ways2H: (Gasification after mixing waste with Ceramic Beads) Sewage sludge to H2 (1T dried Sewage to 50kg H2)
- Bloom Energy (Purifying Biogas from Landfills, WWTPs and using it in Fuel cells to produce Baseload Power)
- Biezel Green Energy (TAD:Thermally accelerated Anaerobic Digestion)
- SGH2 (Gasification)
- Polycrack (Catrogen Unit)
- Boson Energy (High temperature Plasma torches)
- A collaborative project between Southern Company Gas, Electro-Active Technologies and T2M Global is looking to optimize the distributed generation of hydrogen from food waste to reduce the amount of pollution produced from landfills.

- Chinook Sciences' patented RODECS gasification and pyrolysis breaks down hydrocarbons from waste through advanced thermal treatment to release and recover green hydrogen.
- Proton energy: Generating H2 from Abandoned Gas fields
- Standard Hydrogen: (Waste+Sulphur: H2S to H2 and recirculating S)
- Two UK companies, Peel Environmental and Waste2Tricity: Treating plastic with an alkaline solution and sunlight irradiation
- H2e
- Ergostech are developing a production facility that converts sewer-waste into bio-made hydrogen
- Shell : IH2: INTEGRATED HYDROPYROLYSIS AND HYDROCONVERSION
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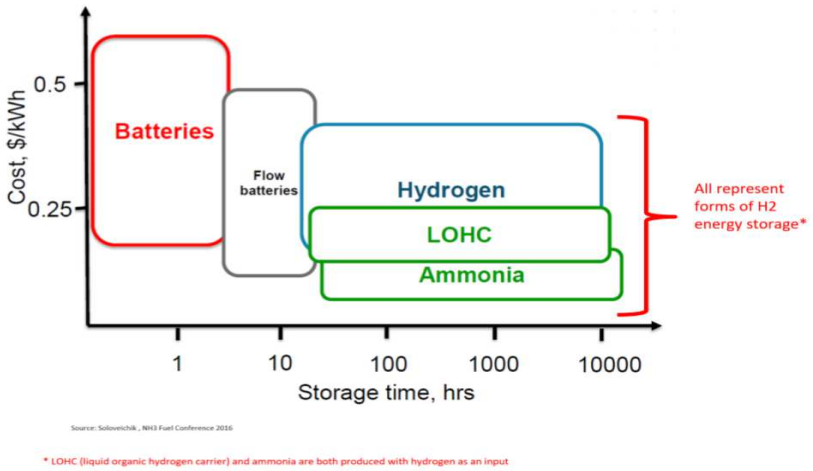
Hydrogen Storage

Hydrogen Energy Storage (P2G) Dominates Long Duration Use Cases that Will Enable the High Penetration of Renewables



Source: Solovelchik , NH3 Fuel Conference 2016

* LOHC (liquid organic hydrogen carrier) and ammonia are both produced with hydrogen as an input

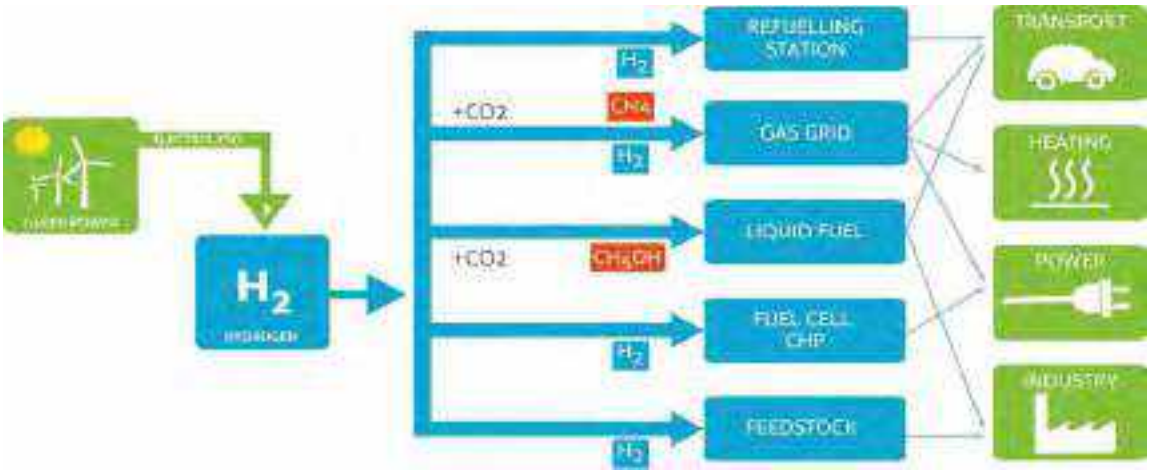
If the hydrogen is produced from renewable energy via electrolysis, the AC-to-AC round-trip efficiency falls to around 35-50 percent, but with Combined Heat and Power efficiency can be 70-85%.

Nevertheless, an NREL study published earlier this year found it would make financial sense to use green hydrogen for energy storage applications with a duration of 13 hours or more — and that's using today's technology.

Out of these alternatives, Hydrogen storage comes out as most economical for long term, having highest storage capacity and retention time with versatile usage.

Hydrogen Storage creates the link between renewable power and green transport, heating and industry.

- Hydrogen can be produced via water electrolysis, splitting water molecules (H2O) into hydrogen (H2) and oxygen (O2) with the use of power.
- If produced from renewable sources, hydrogen can be renewable and completely CO2-free.
- Like electricity, hydrogen can be channeled anywhere it is needed.
- Unlike electricity, hydrogen is suitable for long-term energy storage.
- Renewable hydrogen is a determining factor in fighting climate change, decreasing energy dependency and improving our air quality.
- Power to gas (PtG) conversion systems can help to foster this switch from fossil fuels by providing the possibility to store surplus energy from intermittent sources in the form of hydrogen or synthetic natural gas.
- In addition to generating power using Fuel Cells etc. in times of high demand, PtX also allows for the utilization of this green gas as a fuel or as vital input to various industries.
- Hydrogen gas is required in many industrial processes such as chemical process, refining, material processing, hydrogenation of pharmaceuticals, oils and food products, semi-conductors fabrication, power plant generator cooling, crystal growth and float glass manufacturing.



If excess power is converted to hydrogen through electrolysis on-site, it would reduce carbon foot print in addition to helping grid balancing.

**Data source: The Hydrogen Economy, M. Ball & Esprit Associates 2014*

percent.

Utilizing spare renewable energy

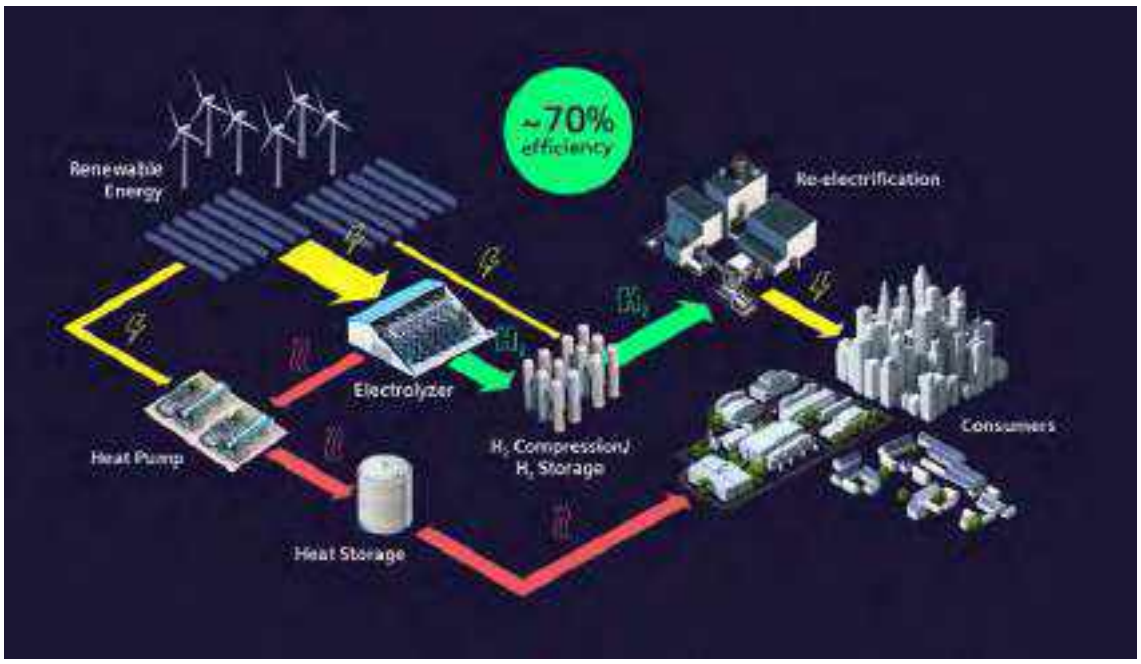
Although this is a global solution, there are obviously areas of the world that make even more economic sense, primarily because of the availability of unutilized renewable energy generation.

Some regions, like northwest Germany, have offshore wind farms that are being curtailed because the grid doesn't have the capacity to distribute the energy to southern Germany where it's needed.

Other regions have a lot of solar or wind power that pushes the electricity prices down to an extremely low level, and even into negative numbers.

In 2019, nine percent of electricity prices in Germany on the spot market were negative. This phenomenon is becoming increasingly commonplace.

There are plenty of other regions where energy can be used to produce hydrogen on a relatively cost-efficient basis, and that could benefit from installing an electrolyzer with hydrogen storage and a co-firing gas turbine.



Thus, Hydrogen production when RE is surplus and using this H2 to produce electricity in times of shortages can provide grid balancing effect. Thus intermittency of renewable energy can be tackled and 24x7 Renewable power along with Green H2 required for mobility and other applications can be made available. Also for remote areas or areas not getting reliable electricity H2 can help in replacement of DGs. Microgrids along with storage, Vehicle to Grid and Demand response can defer capacity addition and also the transmission and Distribution augmentation expenses. Also grid congestion can be avoided. Further microgrids can provide reliable power and heat and hydrogen.

Self -sufficient 9 Flat Housing society in Switzerland

- 2Nm³/h PEM electrolyser - 4.3kg/day -15kW
- Completely off-grid (electrical and gas)
- PV covering entire roof and facade
- Short-term (batteries)
- Long-term (H_2 for 25 days) excess energy stored
- Fuel cell provides heat and power

India: Microgrids with hydrogen fuel cells installed in rural NE India (24 nos. by SFC)

- **Methanol and hydrogen fuel cells provider SFC Energy has completed the delivery and installation of 48 EFOY Pro 12000 Duo fuel cells (500W) for remote sites across four north-eastern Indian States**
- These microgrid solutions, installed at remote off-grid sites, consist of
-2 EFOY Pro 12000 Duo fuel cells: T power 1,000W
-a solar panel of 5,000 Watts,
-a Li-Ion battery bank and
-an intelligent energy management module.
-The AC supply is provided thru a 230V AC inverter

Hydrogen production Means and CO_2 emission:

Means	**CO_2 emitted/tonnes of H2 produced**
Natural Gas	10-12
Coal	17-19

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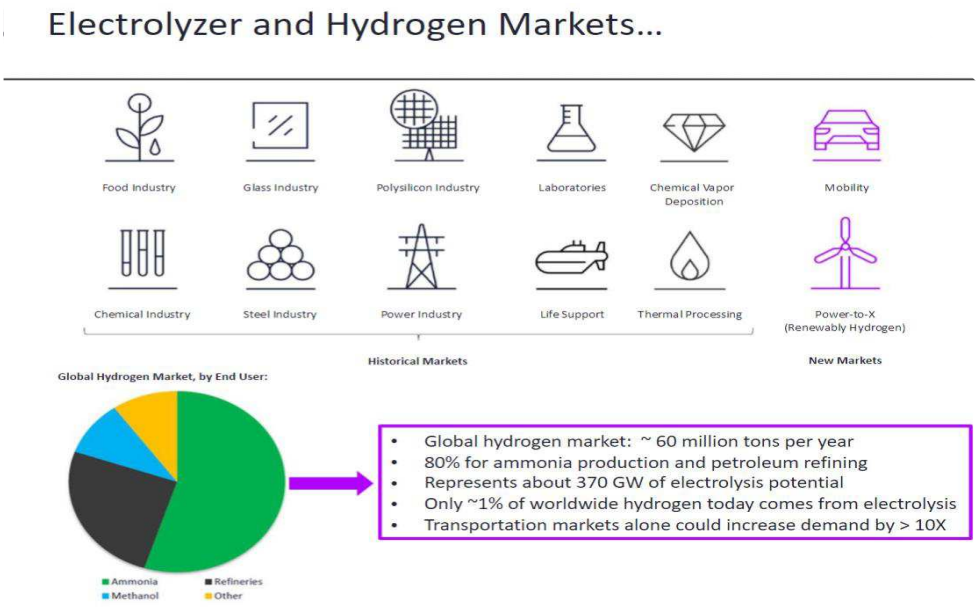


Hydrogen applications around the world

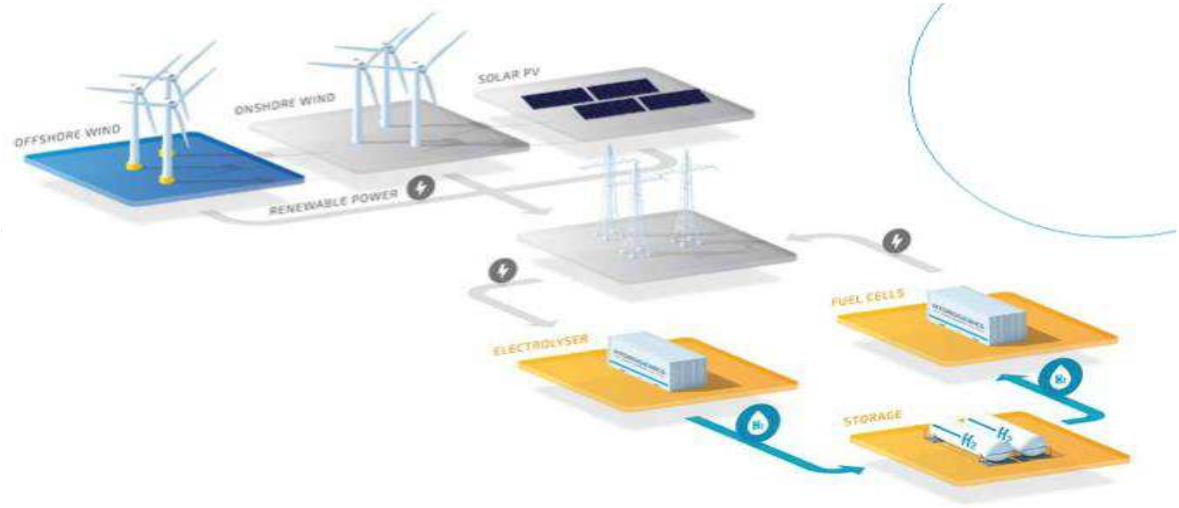
Various Applications of Power to Hydrogen:

- **POWER TO POWER:** Excess renewable energy is converted to hydrogen, stored and then repowered to electricity via a fuel cell system or Gas Turbines using H2 or Blended H2.
- **POWER TO GAS:** To reduce overall emissions from natural gas, renewable hydrogen is injected into the grid, either directly or as synthetic methane using CO2.
- **POWER TO INDUSTRY:** Hydrogen as feedstock for industries and for various uses eg in Steel making, Hydrogenation etc
- **POWER TO FUEL:** Electrolysis produces a clean alternative to carbon - based hydrogen in oil refining or methanol production, reducing the carbon footprint of fossil-based fuels.
- **POWER TO MOBILITY:** Hydrogen refueling stations dispense renewable hydrogen to Fuel Cell Electric Vehicles (FCEVs), making ultra low-carbon mobility a reality.

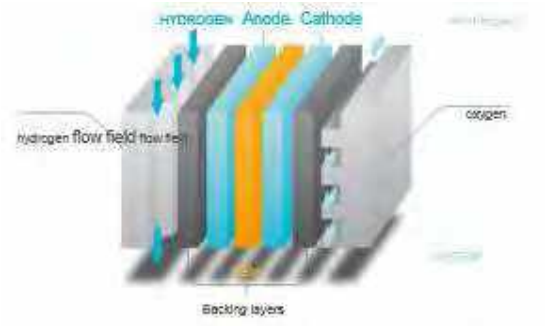
POWER (> GAS) > POWER

Hydrogen, an ideal energy storage solution for isolated energy systems with high penetration of renewable power. Excess sun, wind or tidal energy can be converted into hydrogen by an electrolyser and stored for later use in a repowering unit such as a fuel cell or hydrogen gas turbine. Typical round trip efficiency is around 35% (~70% conversion efficiency from power to hydrogen and ~50% from hydrogen to power).

Hydrogen technologies are a credible energy storage solution especially when highly reliable long-term energy storage (weeks to months) is needed. Typical applications are to be found in remote locations, off-grid systems or islands with high penetration of renewables, Microgrids and 24x7 reliable Power for Data Servers and various Industries and Telecom towers etc. and replacement of DGs.



Fuel Cells (For converting Hydrogen back into power)



POWER TO GAS

Hydrogen or synthetic methane, the TWh energy storage solution

One way to use more hydrogen is to add it to the gas grid, expanding energy storage to the TWh range. There are two techniques for this:

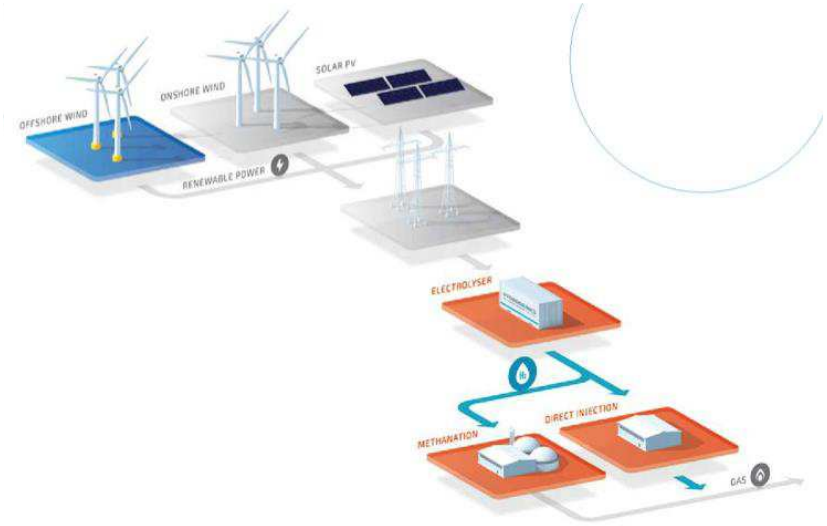
- Direct injection
- Conversion of hydrogen into synthetic methane (methanation).

In direct injection, pure hydrogen enters the grid at a 1-10% concentration (depending on applicable regulation). At up to 2% concentration, this technique is generally straightforward, however above this, the grid operator must confirm grid compatibility and client tolerance for variable H2 concentrations, considering seasonal gas consumption. But even with a 2% limitation, the theoretical storage capacity of gas grid is immense.

Methanation overcomes direct injection's limitations, producing methane that is compatible with natural gas can be added directly to grid. Carbon dioxide and hydrogen are converted into synthetic methane, with water as the by-product:

$CO_2 + H_2 \rightarrow CH_4 + H_2O$.

The process takes place in either high-temperature conversion over a chemical catalyst or biologically via bacteria.



Typical Installations:

1 UNIPER's power-to-gas facility, Falkenhagen, Germany: 2 MW electrolyser

2 BioCat project, Avedøre, Denmark: 1 MW electrolyser

POWER TO MOBILITY

Accessible hydrogen makes fuel cell transport a realistic option. Momentum is building up for a hydrogen refueling infrastructure, with clear 2020 and 2030 targets in national and regional policies across several regions of the world including California, Europe and Japan.

A car can drive 100 km on 1 kg H2, while a bus can drive the same distance on 7-8 kg H2 Both typically travel 400-500 km before they need to refuel. A fuel cell car usually has a 5 kg tank at 700 bar, while a bus tank holds 35 kg H2 at 350 bar

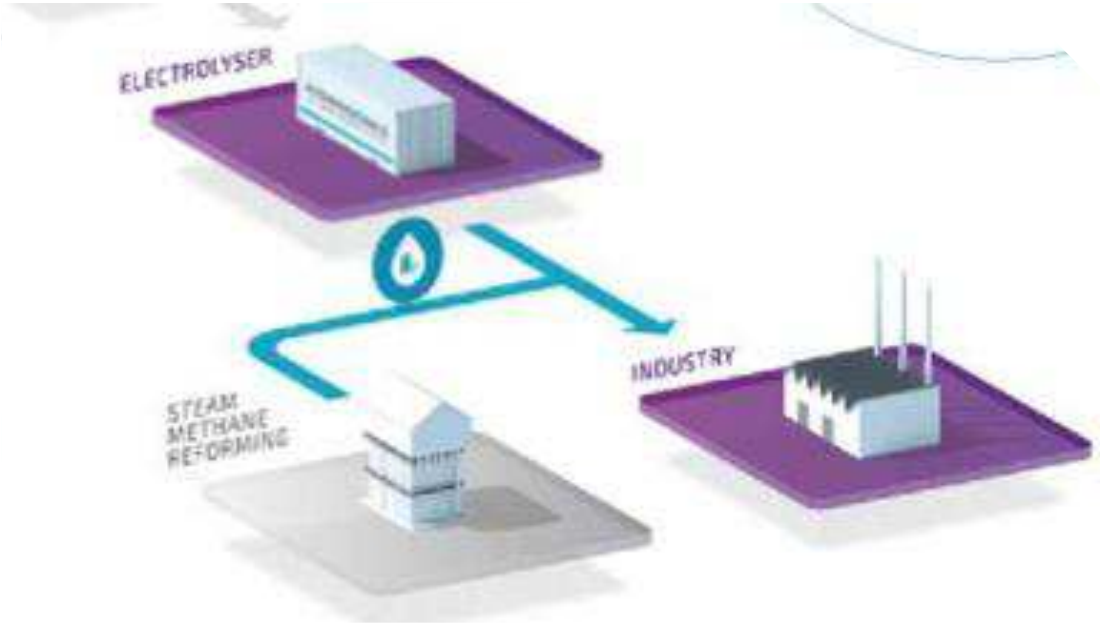
Hydrogen refueling station - technical specifications from Hydrogenics, a leader in designing and building hydrogen-refueling stations:

Electrolyser technology	Alkaline	Alkaline	PEM
Nominal input power	80 kW	500 kW	1 MW
Daily production capacity	30 kg/day	100 kg/day	200 kg/day
Refueling pressure	700 bar	700 bar	350 bar and 700 bar
Compressor	450 bar compressor / 850 bar compressor		
Hydrogen storage	3 banks cascade system sized according to filling requirements		
Dispenser	1 x 700 bar dispenser	1 x 700 bar dispenser	1 x 350 bar dispenser 1 x 700 bar dispenser
Hydrogen Purity	Fuel Cell grade hydrogen at 99.998% according to ISO 14687		
Estimated AC consumption (all included)	68 kWh/kg	65 kWh/kg	65 kWh/kg
Footprint	1 x 40 ft container	2 x 40 ft container	3 x 40 ft container

POWER TO INDUSTRY

Companies across the globe benefit from the reliable hydrogen produced by electrolysers. For example for over 30 years, “Hydrogenics” has supplied more than 500 electrolysers to customers active in power plants, steel and metal processing, glass, oil and fat hydrogenation, small refineries and industrial gas supply. Onsite production gives businesses the flexibility to produce as much high-purity hydrogen as they need, wherever they are. It is especially attractive for remote locations far from central large-scale hydrogen production plants, eliminating high hydrogen transport costs.

By using renewable hydrogen, industries can reduce their greenhouse gas emissions.



Typical Installations:

1 Steel industry, Kirovgrad, Russia: 4 MW electrolyser

2 Float glass industry, Turkey: 1 MW electrolyser

POWER TO FUEL

Hydrogen, a real alternative for creating renewable and sustainable fuels. Renewable hydrogen has the potential to decarbonize significantly the fuel sector, already consuming large quantities of hydrogen produced from fossil resources.

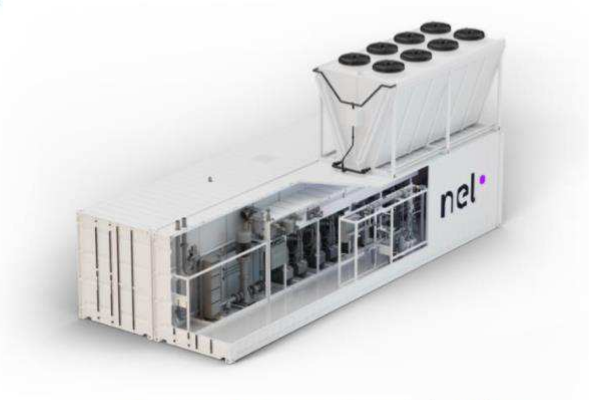
Transport is an area rich in opportunities to limit air pollution by greenhouse gases and particulates, National measures are increasingly focusing on low-carbon transport and sustainable fuels, and hydrogen has obviously an important role to play here.

Today, more than 43% of global hydrogen production is used in refineries to remove sulfur from fossil fuels and for hydro cracking. However, the hydrogen is usually produced from the reforming of natural gas which generates around 10 tons of CO2 for each ton of H2. The 'Power- to -Refinery' concept replaces this with hydrogen from renewables, considerably reducing the carbon footprint of the conventional refineries

Renewable hydrogen can also be used to produce bio-methanol ('Power-to-Methanol') which can be blended with conventional fuels to reduce carbon emissions. Unlike the more complex story of biofuels, these generate pre-determined carbon savings and benefit from very limited use of land.

Power to Gas Conversion

- Electrolyzers can:
  - Smooth renewable generation
  - Provide grid services
    - Operating reserves
    - Frequency regulation
    - Load following
  - Generate a high value fuel



MC400, 2.2 MW Containerized Electrolyzer

Two types of technologies for the cell stack: pressurized alkaline and PEM (proton exchange membrane). The alkaline technology is generally used by industries who require reliable hydrogen production units for their daily operations. PEM is particularly well suited for large-scale applications in the industrial and energy sector.

Alkaline technical specifications

	HySTAT®-15-10/30	HySTAT®-60-10	HySTAT®-100-10
Output pressure		10 barg – 27 barg	
Number of cell stacks	1	4	6
Nominal hydrogen flow	15 Nm³/h	60 Nm³/h	100 Nm³/h
Nominal input power	80 kW	300 kW	500 kW
AC power consumption (utilities included, at nominal capacity)		5.0-5.4 kWh/Nm³	
Hydrogen flow range	40-100%	10-100%	5-100%
Hydrogen purity		99.998%	
		O_2 < 2 ppm, N_2 < 12 ppm (higher purities optional)	
Tap water consumption		<1.7 liters / Nm³ H_2	
Footprint	20 ft container	40 ft container	40 ft container

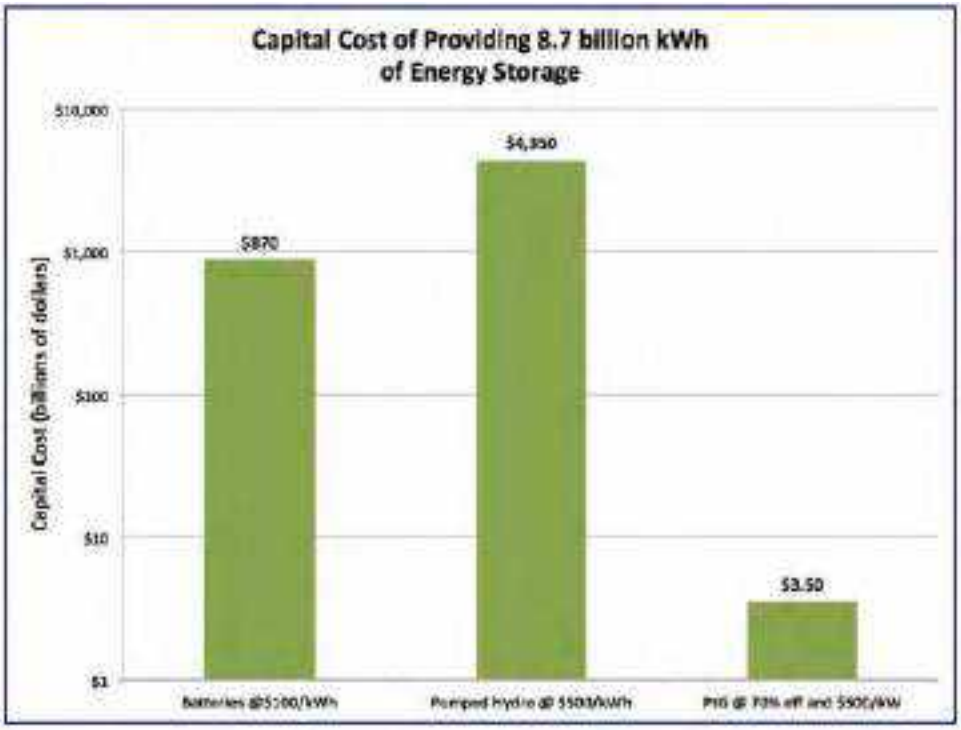
NB: Other configurations (indoor/outdoor) and intermediate hydrogen capacities (10-100 Nm³/h) are possible.

PEM technical specifications

	HyLYZER® -300-30	HyLYZER® -1,000-30	HyLYZER® -5,000-30
Output pressure		30 barg	
Number of cell stacks	1	2	10
Nominal hydrogen flow	300 Nm³/h	1,000 Nm³/h	5,000 Nm³/h
Nominal input power	1.5 MW	5 MW	25 MW
AC power consumption (utilities included, at nominal capacity)		5.0-5.4 kWh/Nm³	
Hydrogen flow range		1-100%	
Hydrogen purity		99.998%	
		O_2 < 2 ppm, N_2 < 12 ppm (higher purities optional)	
Tap water consumption		<1.4 liters / Nm³ H_2	
Footprint	40 ft container	2 x 40 ft container	10 x 40 ft container
Footprint utilities	20 ft container	20 ft container	5 x 20 ft container

Cost of Electricity from Fuel Cells (Fixed Cost and O&M Cost)

Present cost of electricity storage via battery and via conversion to Hydrogen through electrolyzer is already comparable. Storage cost converting to Hydrogen is cheaper if storage time requirement is more than 13 hrs. and it is further projected to reduce very fast.

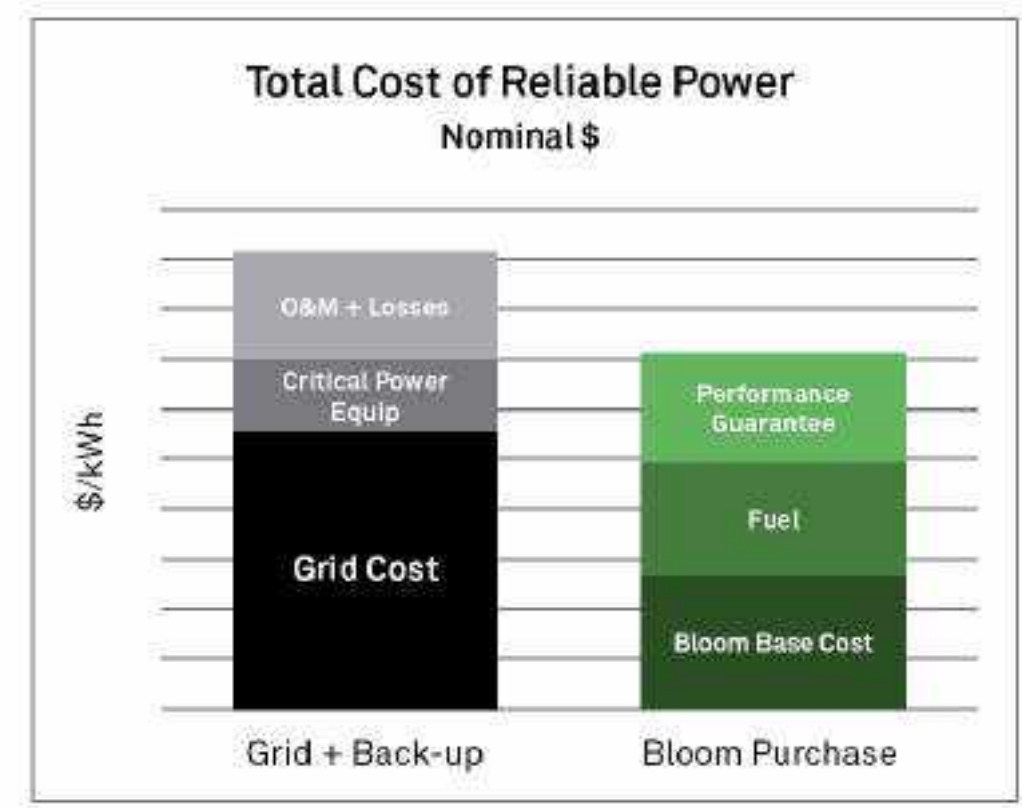


- Effect of electricity pricing variability on the cost of hydrogen generated via electrolysis:

Grid price (cents/kWh)	Hydrogen variable price ($/100 scf)
10	$1.50
8	$1.20
6	$0.90
4	$0.60
2	$0.30

Large-scale delivered hydrogen price

Current cost of SMR hydrogen



Bloom Energy supplies 24x7 reliable power through Fuel Cells for data-servers of Global giants like Google etc.

SFC Energy unveils its brand-new modular hydrogen fuel cell solution (h2-view.com)

Recent Developments

1. Govt of India has formed Hydrogen Energy Mission and its Recommendations are under Preparation. Already 800 crores have been allocated. Circulated draft NHEM on 31/05/21, Fiscal incentives under works

2. Reliance has announce for an Investment of Rs75000 Crores in RE, Hydrogen Electrolysers, Fuel Cells and Energy Storage. Also alliance IH@A has been formed with Chart Industries, USA and some Companies have started joining the alliance.
3. NTPC has recently invited EOI for setting up H2 fueling Station and supplying Power in Laddakh with Solar PV and Hydrogen Storage.
4. An EOI for Replacing DG at EOC with Hydrogen system has been invited by NTPC.
5. NTPC has invited Hydrogen Blending in City Gas Distribution on 13/08/21,
6. Also Studies on Green Amonia for Fertilisers and Green Methanol with Carbon Capture have been done at NTPC.
7. HCNG has already been used in Delhi buses (18% H2 &balance CNG): Bus/Truck pollution down upto 70% wrt CNG
8. HCNG has been Included as Permitted Fuel in Indian Motor Vehicle act vide GSR585(E) dtd 25/09/21.
9. Standards for Safety Evaluation Standards for Vehicles propelled by Hydrogen Fuel Cell have been notified on 23/09/21.
10. **Tokyo Olympics 2020** (23 July to 8 Aug 2021 and Paralympics 24 Aug to 5th Sep 21): Tokyo Olympics have demonstrated Hydrogen ready Village for all needs including Power, Transport, Heating, Cooking etc.
    The Tokyo 2020 Olympic Village is Japan's first full-scale hydrogen infrastructure. After the Games, it will be turned into hydrogen powered flats, a school, shops and other facilities. It's been designed to demonstrate an urban lifestyle that is environmentally friendly, socially inclusive and technologically advanced.
    For the first time in the history of the Games, hydrogen is fuelling both the Olympic and Paralympic Cauldrons in Tokyo and the Olympic Torch during part of its journey through Japan.
    Embodying the spirit of 'tradition meets innovation', the village uses hydrogen to provide heat, hot water and light in dormitories, cafeterias and training

facilities for 11,000 athletes. Electricity used by the facility is generated with hydrogen using pure-hydrogen fuel cells.

The plant in the town of Namie uses up to 10 MW of solar power to produce 900 tonnes of hydrogen each year. Tokyo is also home to what is claimed to be the world's first hotel powered in part by hydrogen derived from plastic waste. The Kawasaki King Skyfront Tokyu REI Hotel has a fuel cell generating carbon-free electricity and hot water used in guest rooms.Worldwide Olympic Partner Toyota has provided a fleet of 500 hydrogen FCEV Mirai cars - the same model used by the International Olympic Committee at its headquarters in Switzerland.

11. Toyota has also provided 100 FCEV Sora buses - the name Sora is an acronym for the water cycle: sky, ocean, river, air - each carrying 79 passengers and powered by 10 high pressure tanks capable of storing 600 litres of hydrogen. A fleet of FCEV fork-lift trucks is being used to transport heavy equipment, and an additional 35 hydrogen fuelling stations have been installed around the city.
12. Under Japan's hydrogen vision, the country has set a target of 800,000 fuel cell vehicles by 2030 and a network of filling stations. There are currently 135 hydrogen refuelling stations in Japan
13. **Green H2 Catapult Targets H2 at $2/kg**
14. The world's biggest "green" hydrogen developers have joined to expand production 50-fold (25 GW by 2026).The companies involved include ACWA Power, CWP Renewables, Envision, Iberdrola, Ørsted, Snam, and Yara
15. Hydrogen Council :is already there having 123 global CEOs from 20+ countries. These incl. Financers, Bankers all working towards accelerating energy transition through H2
16. EU Targets have been launched in "FIT for 55" Program recently. 45000 trucks by 2030 (France 2000 & Netherlands 3000) & 3700 HRS (Hydrogen Refueling Stations) by 2030
17.
18. A hydrogen economy in the U.S. could generate an estimated $140 billion per year in revenue and support 700,000 jobs by 2030, according to a recent McKinsey study published by the Fuel Cell and Hydrogen Energy Association.
19. FCEV Buses are being Run in many countries. In India also IOC has awarded a Tender to Tata Motors. NTPC has also floated a tender. Many Cities are preparing proposals for deploying FCEBs.
20. Shipping Industry has been mandated to cut Emissions by 50% by 2030.
21. Airbus and many new companies are preparing for Hydrogen in aviation and some are running flights already.
22. H2E is piloting 3Wheelers for Logistics with swappable Hydrides.

23. Hydrogen trains are already running in many countries including Germany & China and are already ordered in many more countries. Alstom *Coradia iLint* sold 43 trains. Since Sept'18, world's first hydrogen train is operating in Germany for regular daily passenger services, producing no direct emissions

other than water and incorporating more room for passengers. These new trains are fueled at a mobile hydrogen filling station, where gaseous hydrogen is pumped into the trains' tank to provide enough fuel for 1000km of travel.

24. Indian Railways has also floated Tenders for Converting Diesel Locomotives to Fuel cell hybrids for Kalka-Simla Line and Jind-Panipat Line.

25. India: Microgrids with hydrogen fuel cells installed in rural NE India (24 nos. by SFC)
26. In 2019 HyDeploy piloted blending up to 20 per cent of hydrogen (by volume) with the normal gas supply in part of UK's Keele University's gas network. The hydrogen will be produced by an electrolyser supplied by ITM Power that will be powered by renewable energy sources. Gas safety checks were carried out in the homes and buildings in the trial area, and lab tests were carried out on gas appliances as well as extensive research on the effect of hydrogen on the different materials found in the gas network.
27. ZEFER (Zero Emission Fleet vehicles for European Roll-out) will see a total of 180 fuel cell electric vehicles (FCEVs) in service, divided equally across London, Paris and Brussels. To date, 25 ZEFER vehicles have been added to HYPE's existing fleet in Paris, with HySetCo committing to increasing the HYPE taxi fleet to 600 FCEVs by 2020.
28. The Chinese government is aiming to put a million fuel-cell vehicles on the roads by 2030, from 50,000 in 2025 and last year's 1,791 units, more ambitious than the plans outlined by Japan or in the US state of California. Further South Korea aims to have 1.8 million hydrogen-powered vehicles in service by 2030, with 80,000 units in 2023.

Number of FCVs on the roads

China	1,791	50,000	1 million
Japan	2,926	200,000	800,000
South Korea	900	80,000	1.8 million
California	5,899 (US)	37,400	1 million

Source: International energy agency, South Korea

29. Orkney Islands has an abundance of renewable generation sources (tidal, wind and wave) but it's electricity grid is unable to handle it. To get around this problem, electrolysers from ITM Power have been installed to use excess electricity to produce hydrogen from water. The hydrogen is used to generate electricity for boats docked in the islands' main harbour at Kirkwall, and also for the harbour facilities; the islands are purchasing a small fleet of vans with fuel cell range extenders and installing a filing station; and two local schools on small islands use hydrogen for heat and electricity.

30. Elsewhere, Japan currently boasts the world's largest number of fuel cells in operation by far, with numbers currently nudging a quarter of a million and rising steadily. These are in buildings, providing combined heat and power (CHP). Used in this way, the efficiency of fuel cells at utilising the energy content of hydrogen can **approach 90 per cent**. With the heat transferred to the water, it exits the cell stack at about 70°C, plenty hot enough to run the central heating in a Japanese home. Domestic fuel cell stacks are made by Toshiba and Panasonic (which both make proton-exchange membranes – PEMs) and Aisin Seiki, which makes more expensive SOFCs (solid oxide fuel cells). These are heavily subsidised by the Japanese government to make household purchase affordable (they cost around as much as a car) and are known as Ene-Farms. Their target of 5.3 million units in service by 2030 and is currently on schedule.

Companies already investing heavily in Hydrogen Storage and Applications

- Areva
- Ballard Power Systems
- California Fuel Cell Partnership CaFCP
- Chevron Hydrogen Company LLC
- Chiyoda
- Exxon Mobil QuestAir Plug Power Ben Gurion University Hydrogen JV
- FST Energy
- FuelCell Energy
- Green Hydrogen Company
- HydroGen
- Hyundai
- ITM Power
- Mitsui Co Ltd
- Nel
- Proton Energy Systems Inc
- Proton Power Systems Plc
- Siemens
- Thuga
- Toshiba
- Toyota
- Proton Energy
- FEV
- **Key Indian Companies in H2 economy** : Reliance, NTPC, Tata Power, Cummins, Siemens, Thermax, MTAR, Carborundum Universal, Elgi Equipments, Linde, Tata Motors, Eicher Motors, KPIT, BHEL, Adani

And the Turbine Manufacturers Are Getting Ready…

High-Volume Hydrogen Gas Turbines Take Shape

05/01/2019, Sonal Patel

According to several experts, efforts by companies like Mitsubishi Hitachi Power Systems (MHPS), GE Power, Siemens Energy, and Ansaldo Energia to develop 100% hydrogen-fueled gas turbines have recently shifted into high gear, owing in part to new carbon reduction policies worldwide that have accelerated renewables capacity.

https://www.powermag.com/high-volume-hydrogen-gas-turbines-take-shape/

Vattenfall's Magnum power plant in the Netherlands is shown here. Mitsubishi Hitachi Power Systems (MHPS) has verified that conversion to hydrogen-fired power generation is possible on these units. Photo courtesy: MHPS

- **Coal** power plant (1900MW) in **Utah** is transitioning to **840 MW Hybrid (30% H2/NG fuel) at start-up in 2025 and 100% H2 by 2045**
- Hamburg, Germany: World's first 1MW large-scale gas engine by INNIO Jenbacher begins hydrogen field test: It can be operated either with 100% natural gas or with variable hydrogen-natural gas mixtures up to 100% hydrogen

Roadblocks/Challenges

Main challenge for the large scale implementation of power to gas technologies are listed below:

- Application of new researches and developments to relevant business cases for commercialisation.
- Developing Electrolyser for larger capacities (> 10 MW)
- Efficient and safe storage of hydrogen

- High pressure tanks or new storage media for hydrogen as well as the possibilities to utilize the natural gas infrastructure or geological underground storage facilities need to be further investigated.
- For the conversion of hydrogen to, e.g. methane gas, also the separation of CO_2 from industrial processes or air or the process of biological methanation leaves room for further research.
- To foster large scale energy storage technologies in general and power to gas in particular, regulatory framework is needed to secure use cases like providing ancillary services and reserve capacity as well as producing renewable gas.

Factors influencing the demand for storage and demand side management measures to shift electricity demand need to be analyzed.

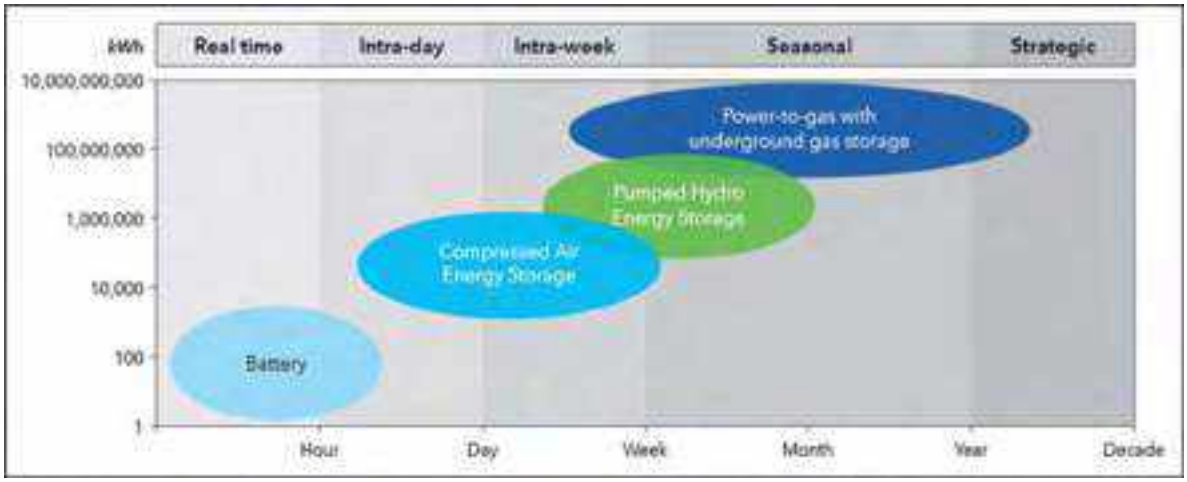
The main challenge is the current high costs of H2 production. Also additional cost is there for storage and H2 transportation from production point to consumption points.

- Market Penetration Restricted by High Cost of Fuel Cells
- Standards for fuelling Stations and Class IV Cylinders still awaited
- Investments required in Infrastructure, Purification, compression, Bottling
- Awareness required for using H2 in Industries like Cement, Steel, Fertiliser etc
- Regulatory & Statuary Approvals for H2 Transport at High Pressure and Permitting more storage at a site
- Zoning requirements wrt Safe Storage of CNG, H2, Petrol, Diesel etc say at a Pump
- Integrated Supply chain Management
- Chicken & Egg Problem even though at Present also cost is competitive (With Scaling and more technologies coming in or maturing costs will go down within 5-7 years just like LEDs, PV etc)
- Academia -Industry-Start-ups-Financers Collaboration required

Way Forward

We need to kick start the process and prepare a realistic pathway with optimized use of available resources and suitable prioritization, Judicious mix of learnings in the short and medium-term and preparing from now itself for the long term can be the right way. Fixing quantitative targets in an ad hoc manner for different components perhaps may not serve any useful purpose. Also clearer vision of energy transition and taking an integrated and holistic approach in developing energy policy focusing on all resources simultaneously with a clear idea of the role each resource can play in overall reduction of carbon emissions.

We must create demand for Green Hydrogen simultaneously by proper policies, regulations and incentives. An announcement for Green H2 purchase obligation for refineries and Fertiliser plants from 10% / 5% from 2023/24 to 25%/20% by 2030 is underway. We must have projects coming up which could use large spare RE for electrolysers and and H2 generated for various applications including electricity generation thus creating demand which can be ramped up quickly.



As more regulations come into play, these industrial users of hydrogen will be incentivized to find lower emission sources for their process inputs. This is where hydrogen from renewable electrolysis can help to meet these emerging regulatory requirements.

Many developed and technologically strong countries have declared ambitious hydrogen policies and their industry has committed large sums of money for not only for R&D and pilots for demonstration, but also for commercial projects and also for the development of needed infrastructure for the production, storage and distribution of hydrogen for various uses. As usage of H2 increases, Costs shall come down on account of scaling and new technological developments in material sciences and

nanotechnology. Dedicated research with the aim to reduce the costs and increase the efficiencies of electrolysers and fuel cells will also contribute to lower costs. Similar thing happened in the case of prices for solar cells, Wind Turbines, Li-ion batteries and LEDs. There are regular announcements of possible breakthroughs and this contributes to a positive outlook.

Suitable locations for Hydrogen valleys where we have the land and water for Green H2 should be identified. A deployment map for 500 GW of solar prepared should be prepared and identified lands should be reserved and preserved, while thinking not only of the best solar locations but also transport of hydrogen and distribution and use of H2 or provisioning for huge infrastructural requirements or costly requirements of transmission. The EU proposes to use the existing natural gas infrastructure with retrofitting at substantially reduced cost for transport of hydrogen.
For India, we need to develop sufficient indigenous manufacturing capacity of the entire solar value chain (ingots, wafers, cells, modules, glass, inverters, etc.), Electrolysers, Fuel cells etc to cut imports. India can become global leader if industry invests in cutting edge technology like Green H2. Reliance Limited has announced 75000 crore investment for these areas including Hydrogen Electrolysers and Fuel cells. Many more companies should come up with intent to establish Gigafactories for the components in the value chain. India can become exporter of H2 by 2030

Hydrogen is best used for long haul heavy transport. Trucks, and even inter-city buses, have eventually to run on fuel cells because batteries are not suitable for these.

Technologies suited for localized biomass-based hydrogen production need to be adopted. This H2 can be stored and dispensed at point of use say at H2 Fueling stations. The other option is to cover the concerned highways for some length with solar panels for production of green hydrogen.

We could even think of dedicated mini metro or bus lines. These can be powered by hydrogen. A prime pilot project can be at the upcoming Jewar Airport at Greater NOIDA as it has linkages to IGI Delhi Airport and Gurugram. The NCR itself could have such a transport system which will enable last mile connectivity. In this case, the new airport terminal can be designed to have enough solar to produce required hydrogen at the point of consumption apart from solar on highways. It is important that we prepare detailed DPRs for above identified mobility projects across the country immediately
We are short of resources, especially as many things have to be done simultaneously; our technology base is somewhat limited; research is rudimentary, and infrastructure very little. We need to have proper Collaboration between Academia, Industry, Venture capitalists and start-ups for enabling right ecosystem.
A dedicated group should be set up with adequate industry participation to plan for the future. This body should start the process of setting up standards as may be required. An empowered co-ordinator or nodal officer should be appointed for co-ordination across various ministries for expeditious approvals as various ministries and departments are involved in setting up various standards and permissions for various Hydrogen Applications.

Manpower for Hydrogen economy should be planned to be made available. MTech course with inter-deparmental orientation and in collaboration with Industry should be started in premier institutes like IITs.
Industries should be made ready to provide special compressors, ,Valves and various other components and control systems etc required to meet demands of specialised Hydrogen applications.

Conclusion

With huge uptake of renewables and the need for grid-scale energy storage to stabilise the energy system, hydrogen would have a real role to play. You can turn it back into electricity, you can put it into vehicles or you can do a power-to-gas arrangement where you pump it into the gas grid.

In the last 120 years, global temperature has increased by 1.2 °C. If the same trend continues, the temperature increase could be 5°C by 2100. The power sector alone represents around 40% of the energy related emissions and 25% of the total GHG emissions with an average global footprint of 520 gCO_2/kWh. Therefore, there is a need to take corrective actions to curve this trend and decrease the potential consequences. The solution is seen as a combination of energy efficiency, biomass use, carbon capture and storage (CCS) and the use of RE. Hydrogen will be an enabler for the energy transition.

Hydrogen Energy Storage systems have the potential to influence transmission planning and the economics of renewables integration and Microgrids. Results from experiences shall provide insights to help guide deployment activities, and policy and regulatory reforms needed to remove market barriers and increase the sustainability and resiliency of multiple integrated energy systems.

Intensive research on electrolyser and methanation technologies is expected to decrease capital costs and increase operation performance by improvements in areas like pressurized operation, temperature control, electrical integration and power electronics.

In a way hydrogen is more relevant than ever. It offers combating climate change through PPP solution- Good for People, Planet and Profits. Ultimately it can result in a win-win situation for everyone.

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World Hydrogen Technology Conventions (WHTC)

Hydrogen Energy Trust

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Hydrogen refueling station solutions by McPhy

Power solutions by Siemens

Energy statistics by CSO, Ministry of statistics and program implementation (mospi.gov.in)

Sciencedirect.com

cleantechnica.com

Achieving automated operations and data driven insights from water/wastewater reuse

In India, solving society's challenges such as water scarcity, access to drinking water, protecting water resources, or reducing its water footprint, Royal HaskoningDHV provides technological solutions that meet these challenges. There has been a consistent demand for software tool to address the O&M, Efficiency and economics issues, which has been truly envisaged in this technology.

With Royal Haskoning DHV's digital innovation, Aquasuite, Nereda and such software built with deep domain knowledge, utilities and industry are able to automate their operations and gain actionable insights on their water infrastructure.

Aquasuite is a proven smart water technology that monitors, analyses, visualizes and controls the performance of water and wastewater infrastructure through predictive analytics and machine learning. Its Artificial Intelligence (AI) - powered analytics and **autopilot** provide full real-time visibility across the complete water and wastewater network, treatment, and controls day-to-day operations. It has helped already thousands of industrial, municipal and commercial assets to:

➢ Reduce energy consumption by up to 15% - 20% ➢ maintain a calm network. ➢ avoid water losses and improve customer service ➢ meet environmental compliance ➢ meet effluent quality regulations ➢ reduce opex costs ➢ turn waste into renewable energy source	➢ Reduces chemical usage in Treatment Plants ➢ Improve produced water quality with upto 50% less Total Nitrogen in STPs ➢ Minimises operational effort ➢ Autonomous, unmanned operation ➢ Extends asset life ➢ Clean and clear dashboards

"In the near future smart cities will have their complete water cycle optimised and operated holistically from one integrated solution:

from source to tap and back again."

Example –
In Delhi NRW (Non- Revenue Water) is approx. 30 to 35%.

From Aquasuite technology, we can save water and decrease the NRW rate upto 3-5% in Indian water Scenario.

Efficient and economic O&M technology with exclusive Software Aid for Water/Wastewater

1. Existing Scenario in a city like Delhi – As a case study

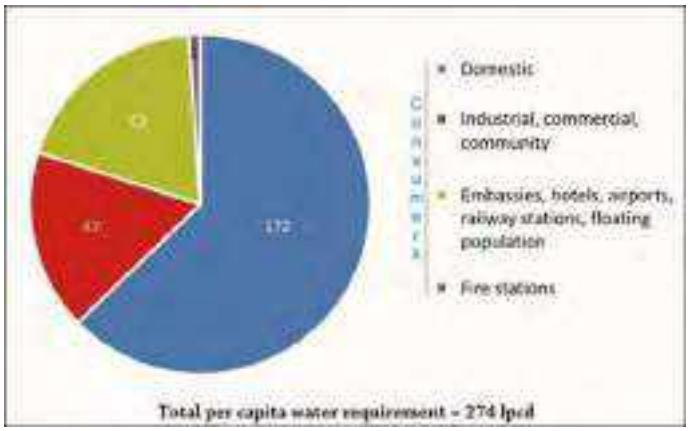
Delhi's infrastructure and services are overburdened by increasing population. The city is surrounded by populous cities (i.e., Faridabad, Ghaziabad, Gurugram, and Noida) that have strong functional linkages with Delhi, and there is massive movement of population on a daily basis for work and other purposes.

Thus, in addition to the residents of Delhi, a large daily floating population requires essential services. Population projections by the United Nations (UN) indicates that the Delhi region will surpass Tokyo region to be the world's most populous urban agglomeration, with a population of over 37.2 million by the year 2028.

Water Requirement

Delhi's daily water requirement is determined considering the needs of the city's permanent and floating populations and is calculated based on people's consumption of water for various purposes.

Per Capita Water Requirement in Delhi



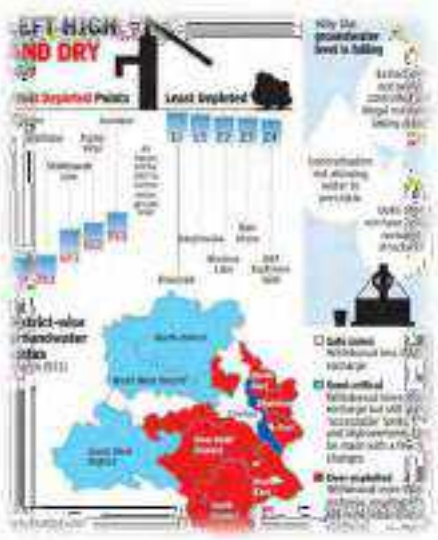
Source: *Planning Department, Economic Survey of Delhi 2019-20.*

Based on a per capita daily consumer requirement of 274 LPCD,

- Delhi's estimated total daily water demand in 2019, for a population of about 21 million, was **1,260 million gallons per day** (MGD).
- It is estimated that the demand is increasing to **1,380 MGD in 2021**, for a population size of 23 million.

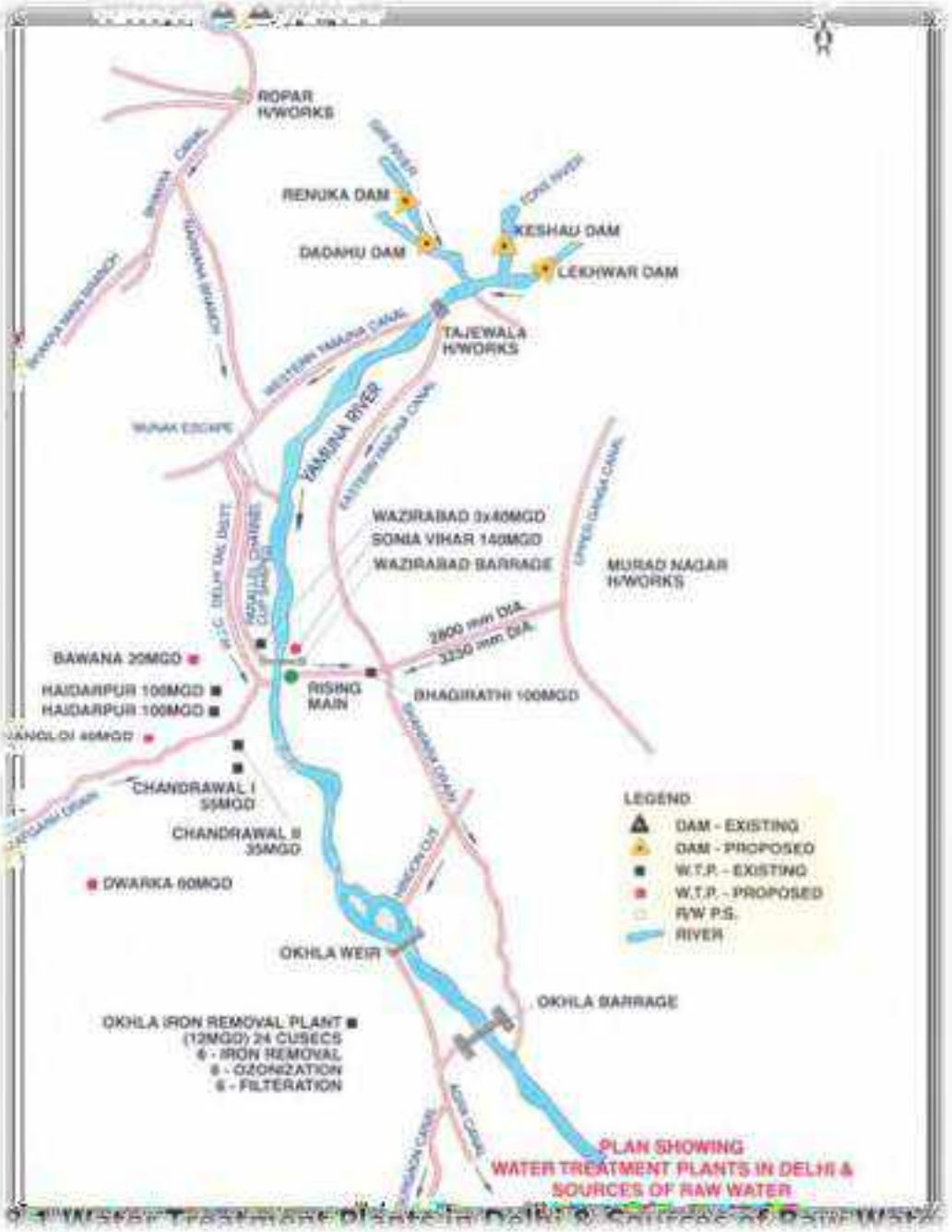
Quality

- **Surface sources (such as rivers and canals)**
  - Many industrial units and untreated sewage drains release untreated effluents in the river Yamuna. Such violations are a worry for Municipal Depts.
  - As a result, the Biological Oxygen Demand (BoD) and Chemical Oxygen Demand (CoD) levels increase, which makes it mandatory to be treated efficiently in the respective Treatment Plants.
- **Groundwater sources**
  - Groundwater salinity is also increasing resulting in Fluoride, Nitrate and Arsenic levels to be higher than the limits prescribed by the Bureau of Indian Standards (BIS).



Coverage

- Because of above factors, It has become difficult to fulfill the daily requirements of water consumption even in the household sectors.
- According to the CPHEEO, an irregular supply of water is susceptible to contamination, and intermittent, low water pressure, also make it necessary for the residents to use electric pumps to lift water from the ground floor to the storage tanks on the top floor causing additional electricity costs



Source: DJB

Disposal

Almost 80 percent (720 mgd) of water supplied to consumers goes down the drain after use, as wastewater. So that it does not cause harm to living beings and the environment, wastewater generated at various premises needs to be transferred safely through underground sewers, and then treated before it is reused for potable/non-potable purposes, disposed in surface water bodies, or used to recharge groundwater. In Delhi, there are many deficiencies in the handling of wastewater.

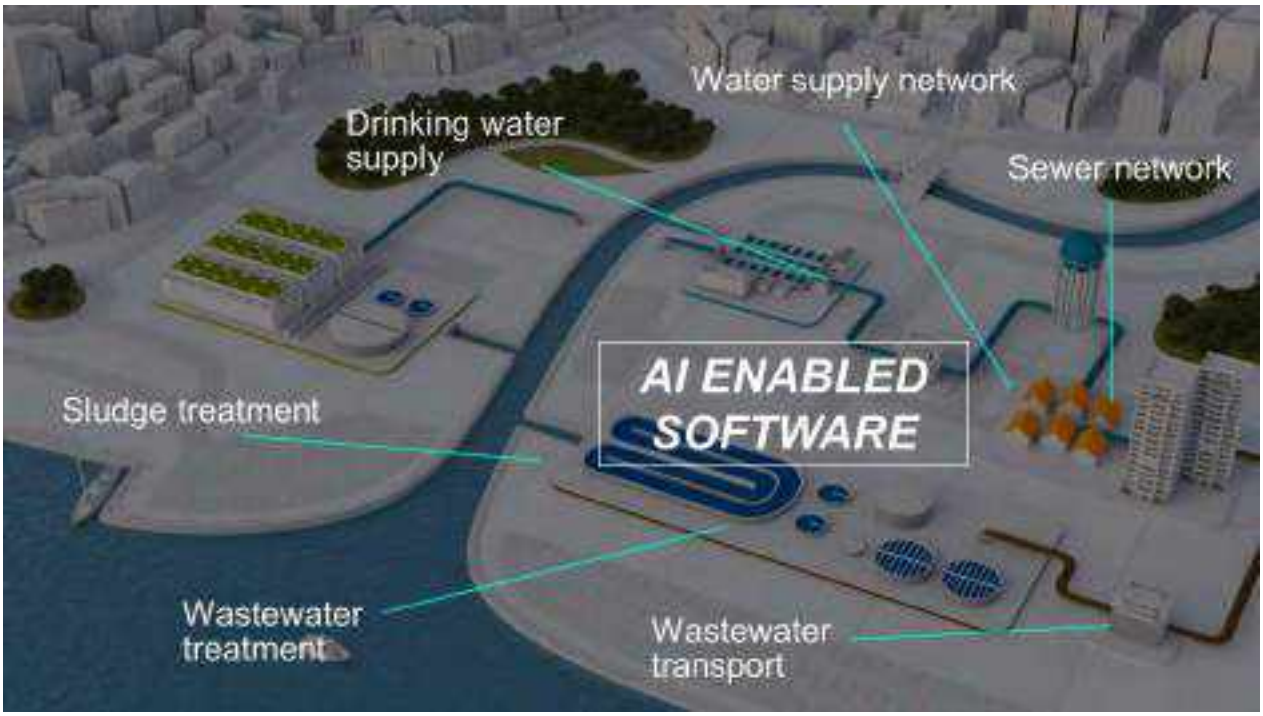
While the agencies like Delhi Jal Board (DJB) had been taking steps for mechanized sewer systems, and nowadays it has become very significant to use Automated systems to fulfill the overall requirement of Treatment by the municipal agencies.

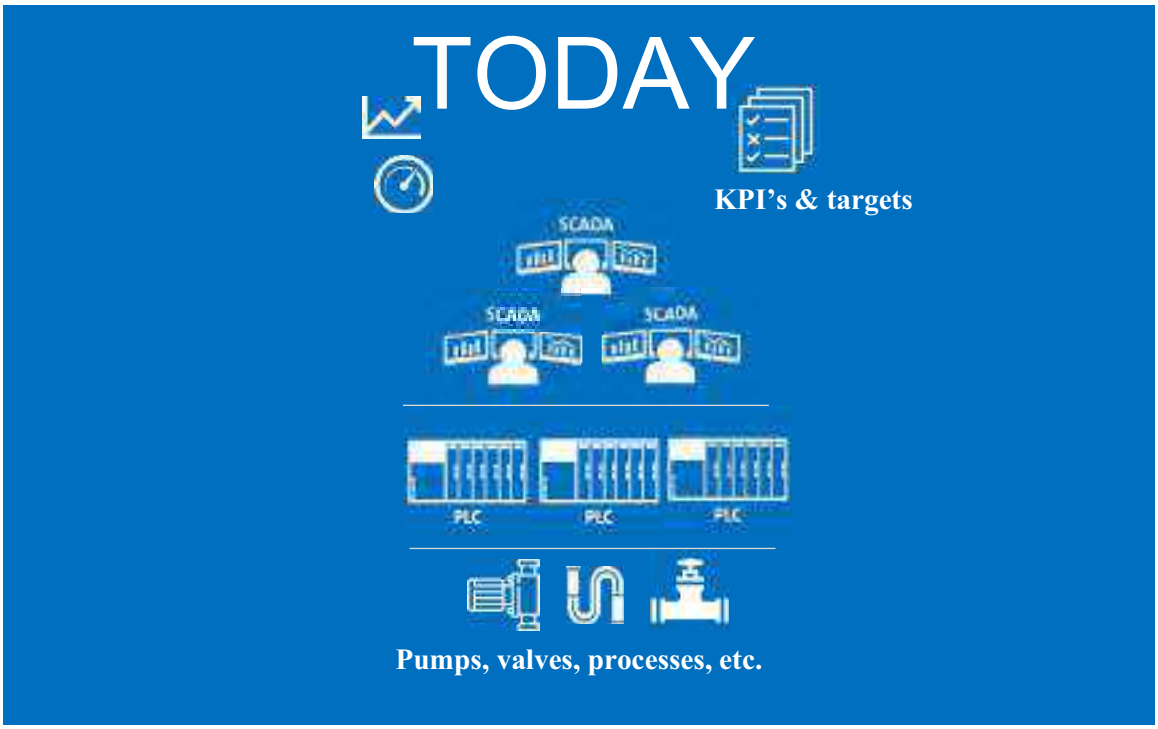
Issues

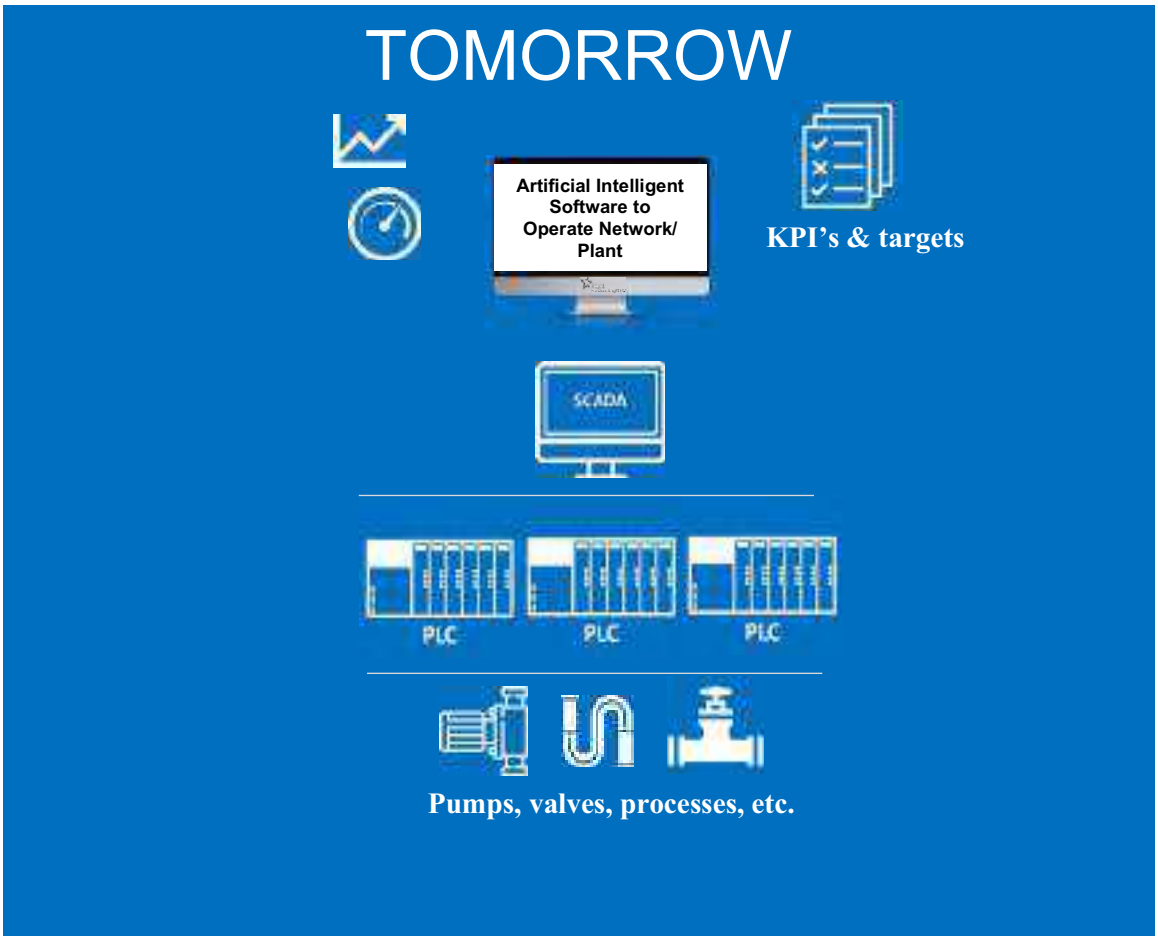
Quantity of Water	– Need to augment production
Quality of water	– Need for anti-pollution measures
Coverage	– Need to improve poor's access to water and sewer
Use of water by consumers	- Need to prevent water losses, wastages.
Disposal	- Need to re-used waste water/ sewage

How Automation Technology can help to control these issues:

Quantity of Water	- Artificial intelligence-based O&M
Quality of water & wastewater treatment	- Continuous Online monitoring for anti-pollution measures
Wastage of water	- Online leak detection to reduce water losses, wastages.
Optimization of Sewer Network	- smart integrated and optimised sewer network.
Optimization of sludge	- To maximum biogas production, higher dewatering and reduce chemical use.

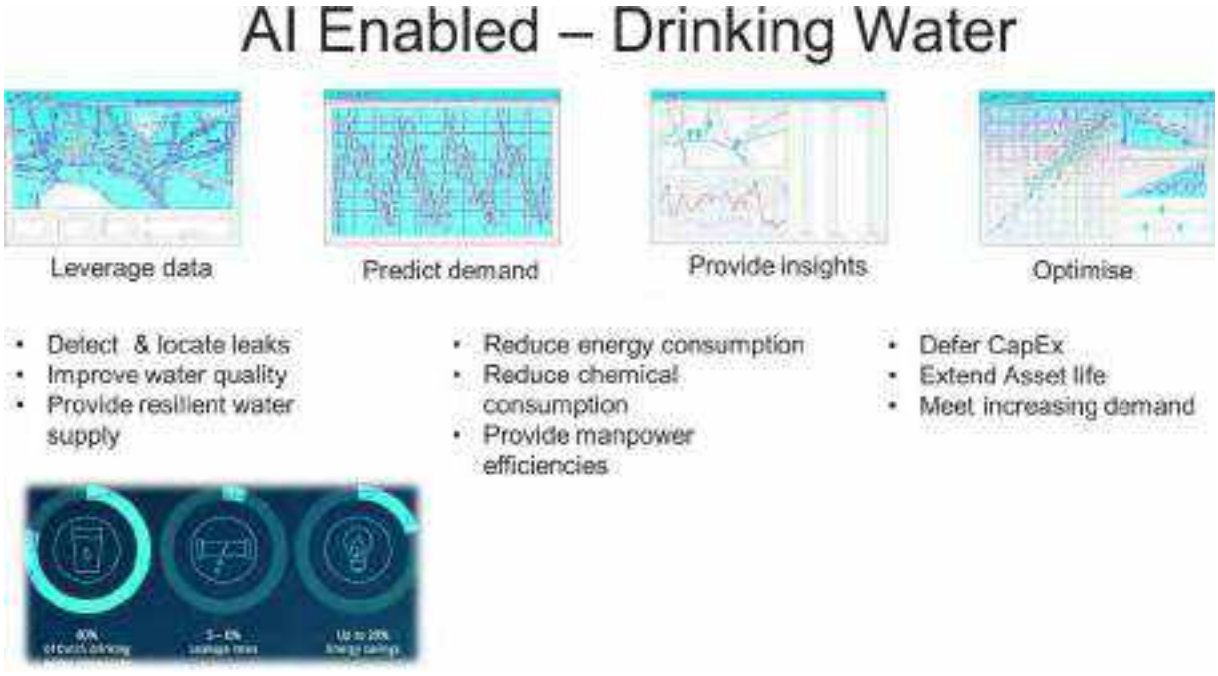



TODAY
KPI's & targets
SCADA
SCADA
SCADA
PLC
PLC
PLC
Pumps, valves, processes, etc.

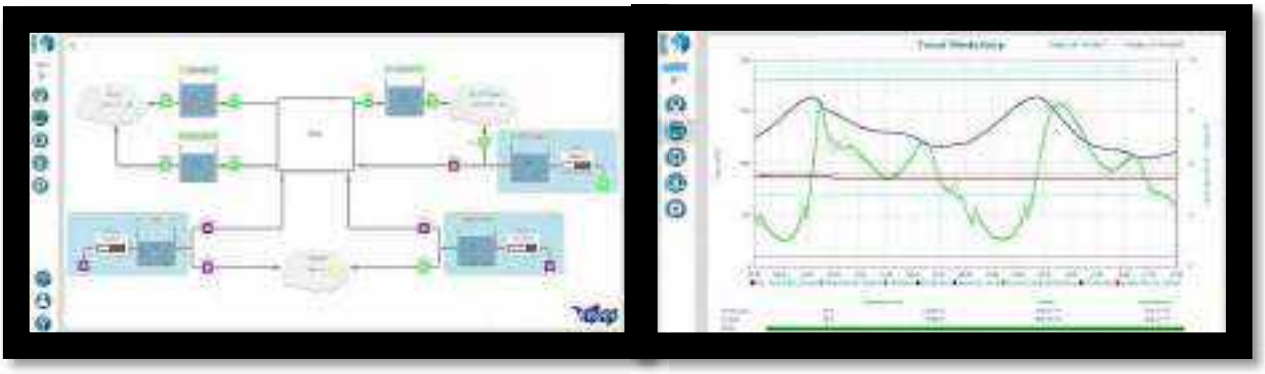

TOMORROW
Artificial Intelligent Software to Operate Network/ Plant
KPI's & targets
SCADA
PLC
PLC
PLC
Pumps, valves, processes, etc.

Only 1 or 2 Engineers, can control and operate for 10-20 WTP/ STPs at a time under the surveillance of AI Enabled SCADA System from Master Control Room.

Ever-growing data flow brings great opportunities for water infrastructure



Virtual operator control & optimisation



Machine learning to optimise production, ensuring:

- Enough water for all
- Best possible water quality
- Efficient pumping

Machine learning to optimise distribution and reservoir level control, ensuring:

- Sufficient storage
- Compliant water age
- Efficient pumping

Machine learning to optimise pressure supply, ensuring:

- Minimum compliant pressure
- Multiple Critical Points are covered

Estimated Non Revenue Water

Maximise use of information – make the data work for you

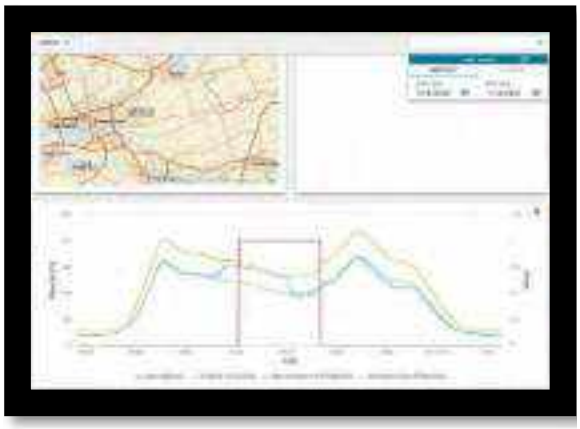
Using AI to detect leaks in real-time

Real time data tested against modelled prediction

Exceptions used to identify leaks, bursts, illegal connections and asset failures

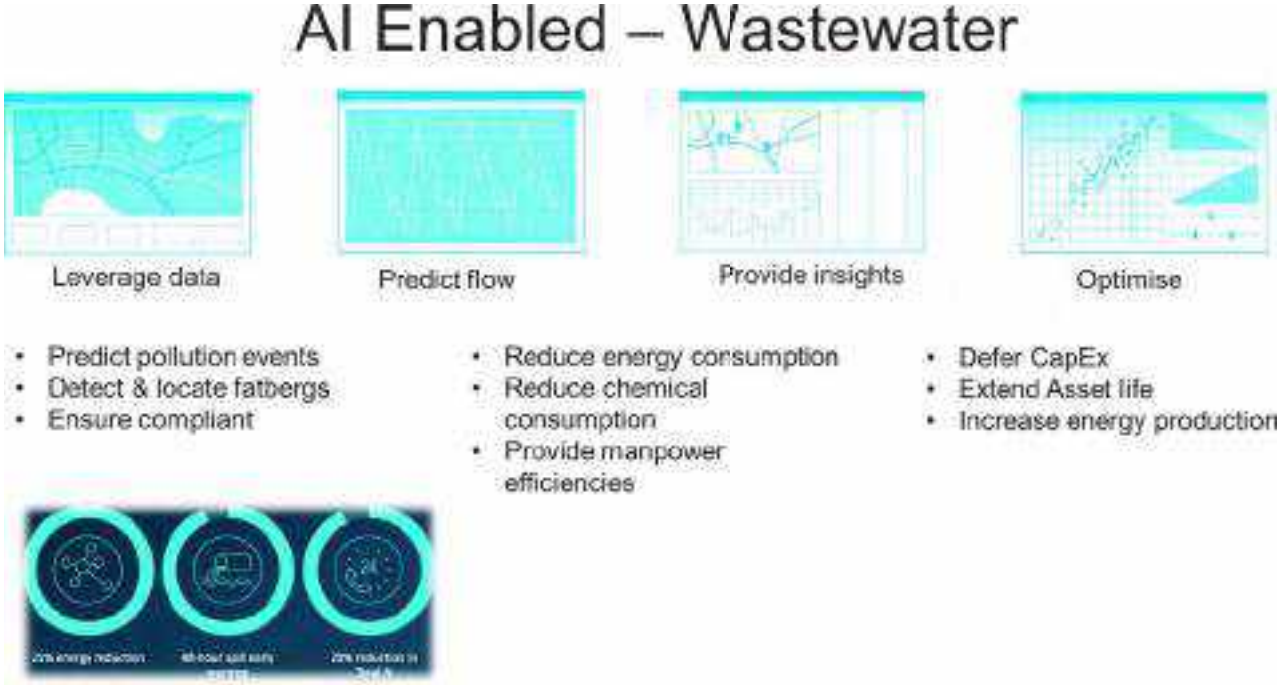
Small leaks become more visible over longer time periods

- Prediction becomes more accurate
- 'Little leaks' detected much faster than traditional limit methods



- ML used to model leak then compare simulated with measured effect at pressure sensor locations
- Leak location is the location where the modelled and measured effect are most alike
- **Using AI to localize leaks in real time**

- Lower water loss and reduced bursts
- Smarter capital investment
- Better customer service & improved efficiency
- **Virtual Operator for wastewater**
- Energy-efficient wastewater transport and treatment for reuse & recovery and meeting environmental compliance.



Virtual operator for wastewater networks

Machine learning to optimise movement & understanding of wastewater

- Blockage detection
- Silt build-up
- Overflow prediction
- Peak flow reduction

Machine learning to improve effluent stability and compliance

- Aeration optimisation
- Efficient dosing
- Anomaly detection
- Early warnings

Conclusion

With the above studies, Artificial Intelligence (AI) will be a proven smart water technology that monitors, analyses, visualizes and controls the performance of water and wastewater infrastructure through predictive analytics and machine learning. Its Artificial Intelligence (AI) - powered analytics and **autopilot** provide full real-time visibility across the complete water and wastewater network, treatment, and controls day-to-day operations. It has helped already thousands of industrial, municipal and commercial assets.

To have certain benefits as follows:

- Reduce energy consumption by up to 15% - 20%
- maintain a calm network.
- avoid water losses and improve customer service
- meet environmental compliance
- meet effluent quality regulations
- reduce opex costs
- turn waste into renewable energy source
- Reduces chemical usage in Treatment Plants
- Improve produced water quality with upto 50% less Total Nitrogen in STPs
- Minimises operational effort
- Autonomous, unmanned operation
- Extends asset life
- Clean and clear dashboards

Emission Regulations In India

Applicable emission Guidelines and regulation for different types of Industrial stacks

Next Generation Emission Monitoring – A Unique Solution

The continuous monitoring of emissions to atmosphere from a broad range of polluting industries places growing demands both on the technology and the modern plant operator, responsible for meeting increasingly strict environmental regulations.
Emission limit values continue to be reduced, additional parameters are requested and data availability requirements are raised. Conversely, the industries reporting emissions increasingly prefer to operate lean and concentrate their limited maintenance resources on core activities. On-line live data reporting and remote access for centralized authorities for validation purposes are further industry trends demanding increasing sophistication of the continuous emission monitoring technology.

This paper will highlight hot extractive CEMS technology in terms of its' suitability to meet current and future reporting requirements.

Reporting Requirements

Emission limit values for compliance are stated as normalised concentrations, mg/Nm^3
i.e. referenced to 1,013 mbar, 0°C, **dry basis** (0 vol-% water vapour) and normalised to a given oxygen concentration (e.g. 3 vol-% O2).
Therefore, the continuous emission monitoring system should either measure water vapour or measure dry basis (water removed before analysis).
However a new requirement in India is to additionally measure flow to report a mass emission.
A mass emission (kg/hour) can theoretically be reported in two ways

1) the flow-meter and the pollutant concentration are both measured dry basis
2) the flow-meter and the pollutant concentration are both measure wet basis.

Since applied flow technologies (preferably ultra-sonic, alternately pitot tube) inherently measure wet, in practical terms the pollutant concentration must also be measured **wet basis**.
Therefore the only satisfactory way to address both emission limit value pollutant concentration and mass emission reporting requirements is for the gas analysis system to measure wet basis, but to include for a direct, continuous measurement of water vapour..

Conventional CEMS Technologies - Cold Extractive

The cold extractive technology is well-known. The limitations of this technique are its' inability to measure significantly water-soluble components and its' sensitivity to the presence of dust particles or contaminating species (acids!). Clearly, it does not combine well with a wet flow measurement. Routine maintenance is needed due to the many sample system elements (multi-stage filtering), yet relatively straight-forward.

Conventional CEMS Technologies - Dilution

Dilution is another known technology, but brings with it a significant consumption of ultra-pure instrument air, so as not to negatively influence the measurement. Due to the use of instrument air, a separate oxygen analyser is required. Since it measures wet basis, yet the water vapour concentration is not measured, there is no clean, direct means to calculate dry basis ELVs.
Finally, the "critical orifice" in the probe, the basis for the dilution, is a small aperture prone to blocking in the presence of particulate matter or entrained liquids (e.g. behind a wet scrubber).

Hot Wet Extractive CEMS Design

This analyser design is known as “hot wet extractive”, because rather than cooling the extracted sample gas to remove water, the sample gas is kept at a high temperature above its’ dew point temperature. So the target gas concentrations are measured in a “hot, wet” condition.
This design features only three elements, a sample probe with a heated filter, a heated sample line and a hot infra-red gas analyser. Each element is thermostatically controlled at a temperature of 160-200°C.
An ejector pump integrated in the hot, wet extractive analyser draws sample gas to the analyser.
Water vapour concentration is directly measured. This allows other measured components to be expressed dry basis. This continuous water vapour measurement is of further value in allowing other measured parameters (e.g. dust concentration) to be expressed dry basis.

Measurement Principle

The measurement principle is based on the absorption of infra-red (IR) light. For each measured component, two filters are selected at respective wavelengths at which the target gas both does (λ_{MEAS}) and doesn’t (λ_{REF}) absorb IR light. The filter wheels rotate to align consecutive optical filters in the infra-red light path as the basis for a multi-component capability. (Fig 1)

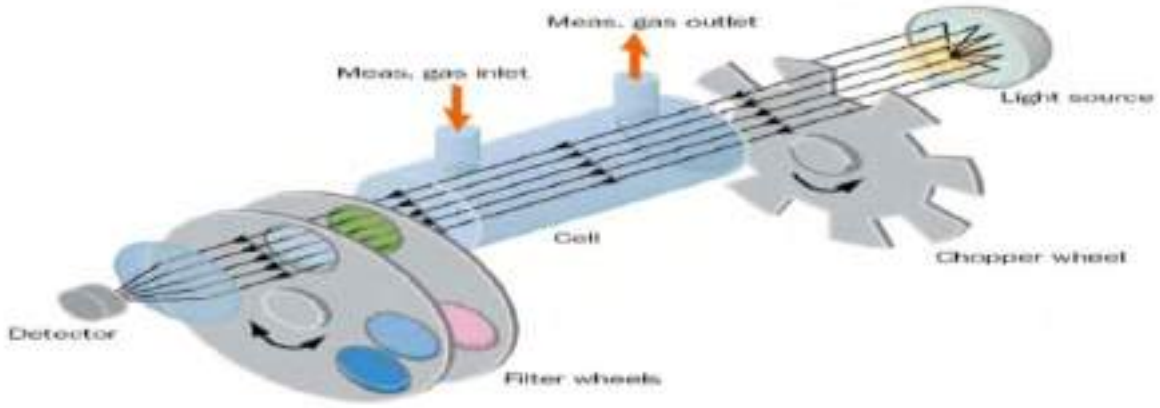


Figure 1 Hot Extractive Analyser Design

The difference in light intensity detected when comparing measurement & reference signals corresponds to each individual target gas concentration.
One major benefit of this design is that both measurement & reference signals are generated from the sample gas flowing through a single cuvette. Therefore any changes in the condition of the cuvette or its optical windows change the light transmission characteristics equally for both measurement and reference signals.

This means that the design is inherently able to measure reliably, even in the presence of appreciable amounts of dust ingress or other contamination, especially when compared with conventional CEMS designs.

The multi-component capability extends to a maximum of twelve infra-red active components and is demonstrated in the table below (Table 1).

Component	Certified range	Additional range
H_2O	0 - 40 Vol%	-
CO_2	0 - 25 Vol%	-
CO	0 - 75 mg/Nm³	0 - 10.000 mg/Nm³
NO	0 - 150 mg/Nm³	0 - 2.500 mg/Nm³
NH_3	0 - 10 mg/Nm³	0 - 500 mg/Nm³
HCl	0 - 15 mg/Nm³	0 - 3.000 mg/Nm³
SO_2	0 - 75 mg/Nm³	0 - 2.500 mg/Nm³
NO_2	0 - 50 mg/Nm³	0 - 500 mg/Nm³
N_2O	0 - 100 mg/Nm³	0 - 2.000 mg/Nm³
CH_4	0 - 50 mg/Nm³	0 - 500 mg/Nm³
O_2 (external sensor)	0 - 25 Vol%	-
TOC (external sensor)	0 - 15 mg/Nm³	0 - 50/150/500 mg/m3

Table 1 – MCS 200 HW Certified Ranges According EN 15267

A single daily zero calibration monitors the intensity of light reaching the detector across analyser lifetime. This "reference energy" parameter is initially set to 100% and establishes an intelligent, condition-based maintenance tool.

A further innovation are the calibration filters (Fig 2), approved for use as an alternative to calibration gases. This avoids the need for "difficult" calibration gases, i.e. that need a wet gas generator (NH_3, HCl) or present safety issues (high concentrations CO, SO_2).

This technology is perfectly suited to remote validation requests from central authorities, such as CPCB.

Figure2 - Certified Calibration Filters

Figure2

The latest version of the hot extractive analyser is operated via a webserver.
Typing in the IP address of the specific analyser gives immediate access from any given location to the full range of analyser data.

Maintenance

Whilst the simple design (probe, heated line, robust multi-component IR analyser) explains the minimal maintenance support required, equally important is that the maintenance required is straight-forward. On-site staff comfortably manage all routine maintenance. A quick remote diagnostics check, can determine when on-site activities from the supplier will be needed.
IR source lamp life is measured in years, not in months, as is the case for UV-based systems.
The expected lifetime of a well-maintained system should be in the range 12-15 years.
Maintenance simplicity compares favourably with other multi-component technologies, for example mass spectrometry and fourier transfer infra red (FTIR) analysers. Whilst these technologies undoubtedly offer a powerful multi-component capability, their complexity leaves end-user technicians with a "black box", meaning an unhealthy total-reliance on the technology supplier and CEMS availability.

Application Perspectives

Consideration of state-of-the art emission monitoring requirements demonstrates the benefits of the hot, wet extractive technology.
As recently as 2020 maritime became the latest industry reporting emissions to atmosphere (IMO 2020).
Of prime importance for ship-based CEMS are minimal maintenance, withstanding significant vibration and self-validation without calibration bottles (limited space, safety issues).
Waste to energy and cement today burn waste fuels that require water-soluble gases (hydrogen chloride (HCl) and ammonia (NH_3)) to be measured as well as conventional components.
Across a range of industries today, abatement technologies such as wet scrubbers or SCR DeNOx systems are increasingly common. Measuring water vapour in condensing conditions or reporting an SCR / ammonia slip (NH_3) emission are now commonplace.

Applications in refineries and petrochemical plants, such as a fluidized-bed catalyst cracker regenerator, de-coker and sulphur recovery unit, are examples where the application demands that the presence of catalyst particle fines & elemental sulphur traces respectively do not result in reduced availability and frequent, intensive unscheduled maintenance of the CEM system.

Summary

The hot extractive multi-component infra-red analyser technology offers a proven, simple design. One key aspect is the ability to directly measure water vapour and so report both dry basis for emission limit concentration values and wet basis for reporting mass emission.
The multi-component capability allows a single analyser to meet monitoring requirements in full with minimal maintenance support. Routine maintenance can easily be performed by on-site technicians. A web server facilitates remote support and remote validation.
The analyser continues to measure in the presence of entrained dust particles or even traces of elemental sulphur. It is perfectly suited to measure behind modern abatement technologies, such as wet scrubbers and / or SCR DeNOx systems.

This unique combination of a powerful multi-component IR analyser technology, which is inherently simple & robust and requires an absolute minimum amount in routine maintenance, suggests that this technology will play a central role in the future of continuous emission monitoring.

Exploring Analytics Potential in Artificial Intelligence

-Jyoti Dhar, ASSYSTEM STUP

Abstract:

Data is dead, unless analyzed meaningfully. Yes, this is the importance of analytics. What is Analytics? In Short, Computational analysis of data in a systematic manner is Analytics. One of the important aspects of analyzing the data, is to look for meaningful patterns from it. Once discovered, the meaningful patterns need to be interpreted in a desired manner to be further communicated to its desired destination for final decision making.

Conventional Analytics used to be quite cumbersome and time consuming. Artificial Intelligence plays an important role not only to create a paradigm shift in the domain of analytics, but also such a shift is changing our world very fast. Combined with potential of data generation using IoT platforms, Advanced Analytics has revolutionized our Industrial world tremendously.

Introduction:

Unless we translate good ideas quickly into innovative products and services, we can't drive our generation towards prosperity and ensure their better quality of life, by addressing the challenging issues like sustainable and smart urban development, environmentally friendly energy, individualized medicine, and digital society etc.

The way our universe is ever expanding to limitless infinity, our world on this planet earth is also exploding and ever expanding, with data coming from myriad sources. To deal with such ever increasing data in a meaningful and purposeful manner, is a big challenge. Translation of good ideas into meaningful innovative products and services, can only be achieved provided we intelligently extract the right set of knowledge from this ever-expanding data with its timely application for a real practical purpose.

No doubt connectedness of data sources and their characteristics are an important factor, but more important factor is to process such data and extract intelligently the knowledge, at times in a real time mode for mission critical situations, which goes in the long way for smooth and autonomous operations of many real-life systems, either themselves as innovative products, or services or as intelligent manufacturing plants, based on industry 4.0 standards, to produce such innovative products.

To harness full potential of Analytics in the form of **Advanced Analytics** in the industrial world, underlying platform in the form of connectedness of things, is equally important to ensure continuous flow of data from such myriad sources.

The **Internet of things** (**IoT**) does provide such connectedness. Kevin Ashton of Procter & Gamble, in 1999, first used the term "the Internet of Things".

The **Internet of things** enables connected devices to collect and exchange data. Connected devices could include physical devices, vehicles, buildings, embedded with

electronics, software, sensors and actuators, etc. Global Standards Initiative on Internet of Things (IoT-GSI) defines IoT as *"a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual)* ***things*** *based on existing and evolving interoperable information and communication technologies".* A ***"thing"*** is "an object of the *physical world* (physical things) or the *information world* (virtual things), which is capable of being uniquely identified through its embedded computing system and interoperable and integrated into communication networks of existing internet infrastructure."

Things in IoT could be sensed or controlled remotely across existing network infrastructure, to ensure more direct integration of the otherwise physical world into computing systems, thus leading to more autonomous systems with less human interventions, resulting in improved efficiency, accuracy and economic benefits. In fact, IoT could be considered as a specific instance of Cyber Physical Systems, whereby it is augmented with sensors and actuators. Cyber Physical Systems, include smart homes, smart grids, smart cities, intelligent transportation, virtual power plants, autonomous automobile systems, robotics systems, auto pilot avionics, process control systems, medical monitoring, etc. By 2021, it is expected that there would be around 30 billion objects constituting IoT.

No doubt in future, world is going to be driven by connectedness of various diverse entities, platform for which is provided by IoT, this connectedness is of no use, unless the data exchange on this platform is intelligently generated, driven, processed and applied.

Originally IoT did not include the concept of autonomous control, Intelligence ambient or artificial. Autonomous control, Intelligence ambient or artificial, do not require the existence of Internet platform for being in action. But IoT is being evolved to integrate the concepts of autonomous control, and Intelligence to drive the futuristic life based on autonomous IoT. Future IoT though open would also be a non-deterministic network having interoperable auto-organized intelligent entities, virtual objects acting independently based on the context, circumstances or environments. Though many IoT products and solutions available in the market use different context-aware automation technologies, yet more sophisticated and advanced kinds of intelligence are required to leverage this connectedness to the full extent.

Intelligence exhibited by machines is Artificial Intelligence(AI). It is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages, machine learning etc. It has all the potential to drive the future of the connected world wherein voluminous data gets generated in real time mode, and to embed Intelligence in Big Data Analytics to ensure smooth and autonomous functioning of systems, where at times even human intervention may also prove indecisive and even impractical.

Advance Analytics and use cases in Water Technology:

Compared to conventional analytics which involves traditional business intelligence (BI) tools like statistics, computer programming and operations research to quantify performance, advance analytics involves autonomous or semi-autonomous analysis of data using sophisticated techniques and tools like machine learning, decision trees, logistic regression, linear to multiple regression analysis, predictive modelling, unsupervised Machine learning like Network and Cluster Analysis, Principal Component Analysis, Segmentation Profile Analysis and Association analysis data/text mining, pattern matching, forecasting, visualization, semantic analysis, sentiment analysis, multivariate statistics, graph analysis, simulation, complex event processing, neural networks, image processing to discover deeper insights, make predictions, or generate recommendations.

Optimizing water and sewage treatment plants by leveraging related data to have efficient processes and reduce energy consumption has become all the more need of the hour. The underlying IoT platform is used to **Gather** historical and real-time SCADA, water quality data, flow data, and other relevant data points which artificial intelligence uses to **Analyze** and **Forecast** operating conditions and **Recommend** the optimal treatment conditions for plant operators to finally **Act** on the ground. The objective of this approach is to create one centralized real-time decision support system to optimize Plant Performance by way of lowering concentrations of pollutants in effluent, establishing economically all the regulatory compliances, reducing aeration energy consumption rates, reducing chemical consumption, diagnosing faults to respond any equipment failure in real time, in any complex treatment plant and.

Some real life uses cases of advanced analytics are as follows:

1. Identifying filament upsets to detect and avoid issues. Filaments are bacteria and fungi that can be both positive and negative. Positively, they can add stability to the floc structure. Negatively, they can cause foaming and bulking.
2. Addressing sludge expansion problems and improving aeration and pump efficiency.
3. Predicting equipment failures with sensor data from motors.
4. Controlling daily flow and monitoring the systems and automation processes.
5. Improving operational efficiency and reducing costs.
6. Identify early abnormal sensor behavior thus warning any asset degradation or failure, in advance using machine learning.
7. Monitoring energy consumption of equipment.
8. Large disturbances and uncertainties in influent flow rate and pollutant load, are

handled by predicting future effluent quality and plant maintenance time.

9. Automating sampling and testing processes to provide recommendations in real time mode.
10. Unearthing previously hidden issues within large datasets generated in real time, which otherwise required expensive services of data scientists.

Session – 3

Overview of ISA/IEC 62443 Standards for Security of Industrial Automation & Control Systems (IACS)
(Abstract of Technical Paper on Cyber Security – Surveillance in Automation)

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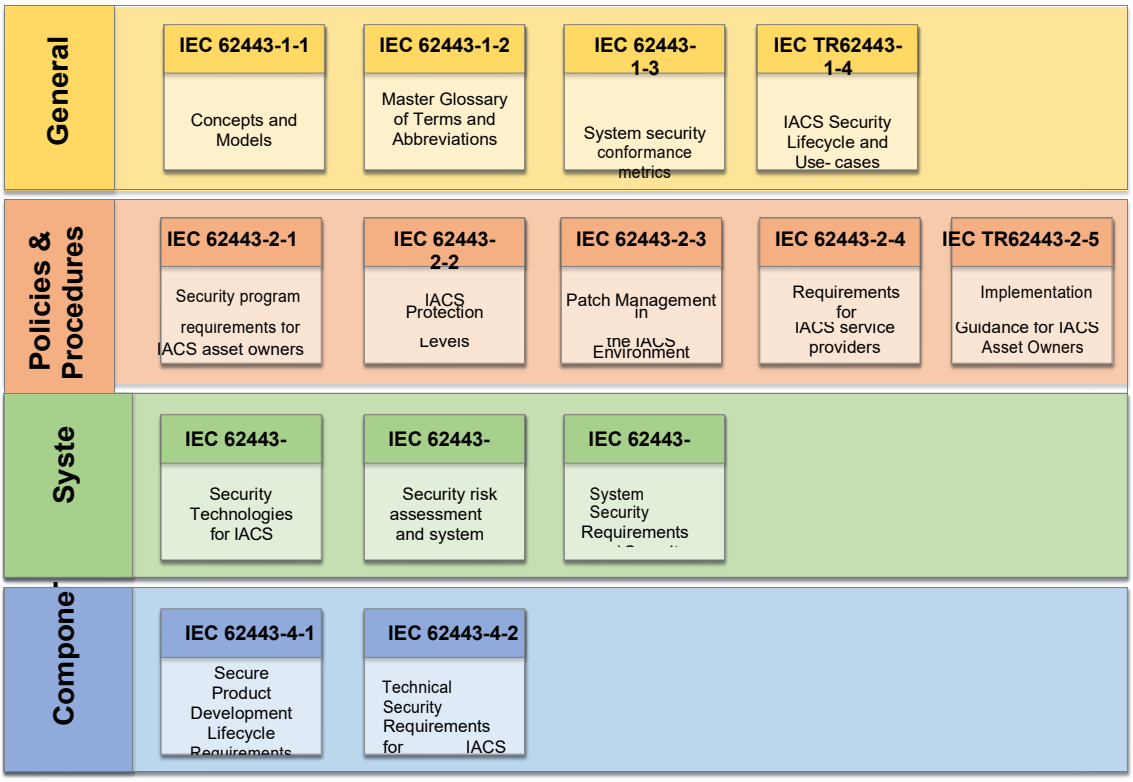
Proactive cybersecurity efforts are on the rise. A recent global security survey showed that 54% of industrial control systems have experienced a cyberattack within the last two years. Cybersecurity has quickly become a major priority for automation systems of all types and sizes, especially for Safety Instrumented Systems.

ISA/IEC 62443 committee have created a set of standards to help protect manufacturers, end users, and people. The ISA/IEC 62443 document series is an international standard intended to provide a flexible framework to enhance Industrial Automation Control System (IACS) cybersecurity.

Completely avoiding cyber-attacks is likely not possible, but significantly decreasing the probability of a successful attack is feasible by following the guidelines of ISA/IEC 62443 standards. Most of the recent security breaches could have been avoided by following the best practices described in these standards. The ISA/IEC 62443 series of Industrial Automation & Control System (IACS) Cybersecurity standards are rapidly becoming the defining document set for cybersecurity protection features and engineering processes in the operational technology (OT) space.

This Paper will provide a brief overview of the IEC62443 family of standards.



Some of the relevant / commonly referred standards as explained briefly in this Paper

IEC 62443-2-1	This standard is mainly targeted towards end users. It is important for end users to recognise that they have the ultimate responsibility of security of the IACS. This standard defines the requirements to develop a Cybersecurity Management System for their Industrial Automation Control Systems (IACS). This Paper will briefly explain Security Program Elements of this standard.
IEC 62443-2-4	In today's scenario, most of the cybersecurity services are outsourced by end users to services providers. The IEC 62443-2-4 documents a comprehensive set of requirements for security capabilities for IACS service providers such as System Integrators or maintenance service providers. This Paper will cover the structure and key concepts from the standard, as well as introduce the 'maturity' model as a means of measuring the quality of an integrators cybersecurity management system versus the requirements of IEC 62443-2-4.
IEC 62443-3-2	Cybersecurity is a process that requires continual risk assessment, assigning Security Level (SL) targets and risk reduction via the mitigation of identified threats. This Standard provides guidance to assess the current cybersecurity risk profile, take steps to reduce cybersecurity risk through network segmentation, system hardening, and improved cybersecurity awareness, as well as monitoring cybersecurity during operations and maintenance. As the Security Level (SL) targets and capabilities are defined, cybersecurity metrics become necessary to be able to assess the efficacy and comprehensiveness of the design. Through the usage of well defined, repeatable, and accurate cybersecurity metrics, SL adequacy can be assessed. These Security Levels are organized into four increasing tiers each requiring more stringent controls be in place.
IEC 62443-3-3	This standard document the System Security Requirements and Security Levels based on the seven foundational requirements for achieving robust system cybersecurity. Seven core functional requirements are used to assist with the design, development, testing and construction of an integrated security architecture. These requirements can be applied to control systems and integrated industrial automation (either implemented in-house by an end-user or provided as an automation solution by a service provider). This Paper will cover the structure and key concepts of the IEC 62443-3-3 standard.
IEC 62443-4-1 IEC 62443-4-2	The IEC62443-4-1 (Product Development Lifecycle Requirements) and IEC62443- 4-2 (Technical Security Requirements for IACS components) standards were specifically created for developers of industrial control system products such as PLCs, DCSs, SISs, RTUs, VFDs, etc. with the Software Developer's roles and responsibilities in mind. This Paper will briefly explain the process and benefits of a Cybersecurity Certification.

Industrial Network Security Architecture

Over the past decade the world of industrial automation has adopted ethernet as a universal communication standard to the detriment of previous RS232/485 cereal communication systems. The reasons for this are multiple: Ethernet has been shown to maintain the availability and real time requirements of the communication between industrial control systems (ICS) and the rest of the devices, in addition to providing a vendor independent ecosystem. Moreover, industrial Ethernet networks allow for transparent connections with external networks at speeds several orders of magnitude greater than industrial communication systems.

The greatest number of opportunities and threats (particularly security threats) can be found when connecting to systems outside the production operational area- such as the Internet or third-party networks, for example. Professionals must take these topics into account when designing an ICS that is to be part of industrial Internet of Things (IIoT) environment.

The industrial network security architecture provides a network reference guide for both operational technology (OT) and information technology (IT) professionals, who collaborate to provide services such as:

- connectivity to previously isolated machines

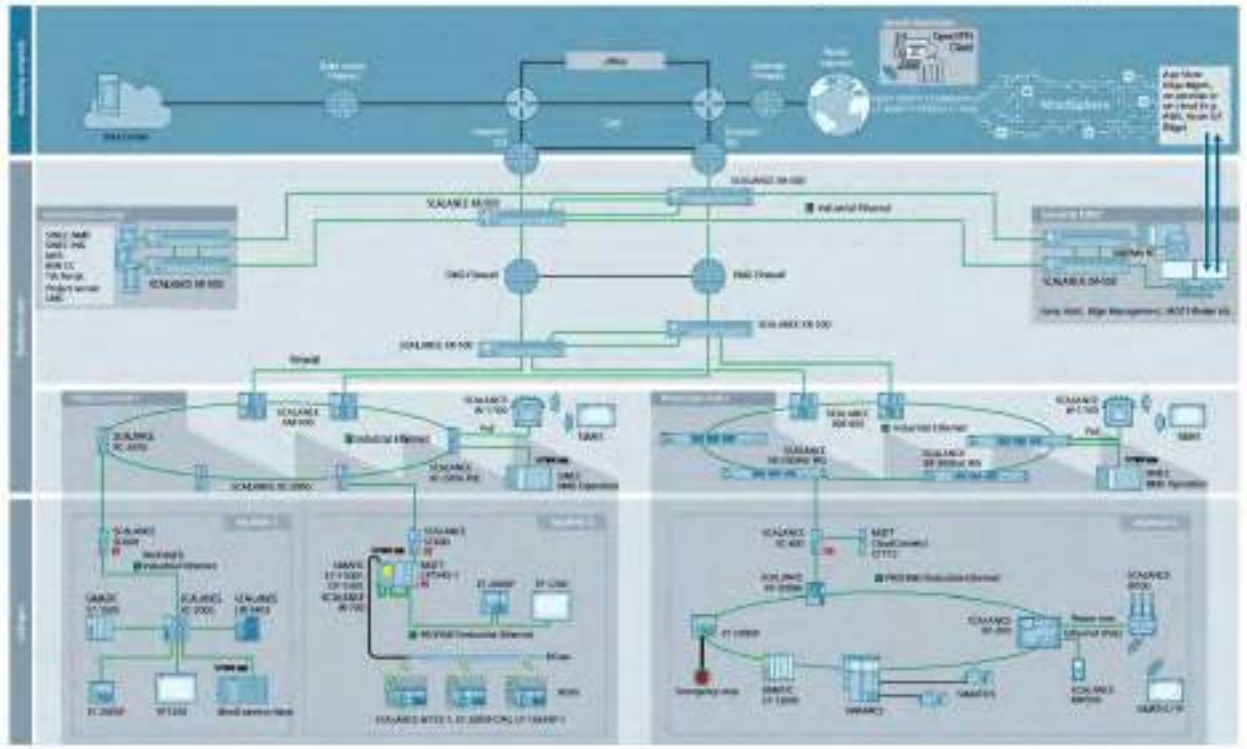
- remote access to machines in the factory

- processing of production data via edge and cloud computing

- providing a secure network design from cell to industrial backbone level

A secure network is a network that has security measures in place that helps protect it from attackers. Of course, there is no such thing as an entirely secure network. However, taking the proper steps helps keep a network secure. The architecture is a template based on experience gained from multiple customer projects and industries.

Figure 1: Network architecture application example



The industrial network security architecture is based on the recommendation of international industrial security regulations, where it is emphasizes that organizational processes for cybersecurity are as important as the technical solutions. Most international standards, such as NIST and ISA/IEC-62443, apply the concept of multiple barriers detecting and preventing a threat that may endanger critical information, goods to be produced or the integrity of data.

To implement security on any current industrial automation project, it is necessary to follow a holistic approach combining several solutions that support each other. A cybersecurity plan must include the following steps and procedures.

1. **Network Segmentation:**
   It is necessary to divide the plant network into separate protected zones, following criteria that is either functional or technical. This limits a failure of a particular of the neck don't and prevents an uncontrolled spreading across the plant and operation. OT and IT staff must work in close cooperation to design a zone-based architecture that best fulfills both cybersecurity and production requirements.
2. **Asset Management:**
   network operators often face the challenge of knowing their installed base of factory assets. This is a prerequisite for the security concept. Therefore, it is strongly recommended to use a network management system (NMS) capable of automatically detecting all active devices. Based on this, the NMS provides a complete asset list with the additional information of each device, e.g. device name, serial number and firmware version.

3.Network Protection:

To properly divide the network into zones, it is necessary to define communication relations between the different zones of the factory. Based on these relations, policies must be implemented on each firewall protecting a zone. Additional insights can be gained by using solutions capable of monitoring traffic in real time, detecting anomalies, and reporting incidents.

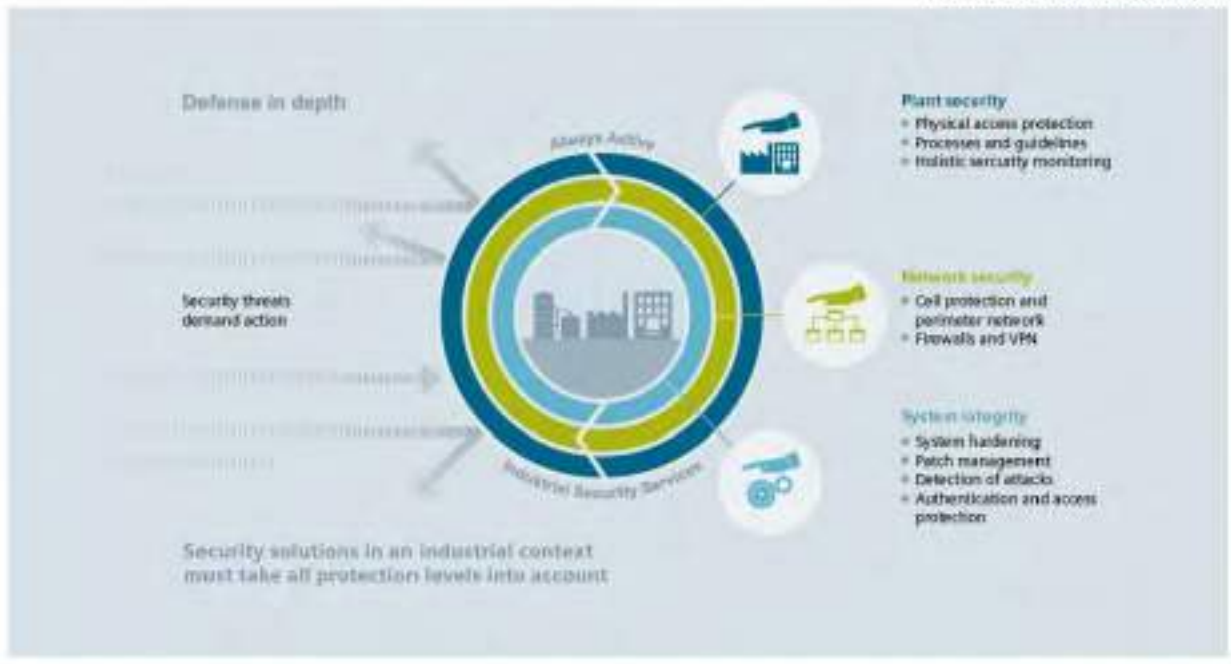
4.Secured Remote access management:

For ICS maintenance, diagnostics purposes, patching and updates different suppliers must have access to OT level sales from outside the factory via the Internet or from other untrusted areas unrelated to production. This requires a remote solution, establishing a secure connection out of the cell towards a rendezvous server to be compliant with the protection measures and security policies. Each remote user has its own access rights via encrypted communication. Manual management of this access is not state of the art and subject to failure. Therefore, it is recommended to use a centralized secured remote access and user rights management solution (User Management Component) that integrates with the corporate access policy tool.

5.Training and Awareness:

The biggest threat to the security of a facility is lack of knowledge and lack of information. The cybersecurity plan must always include employees, business partners and visitors, regardless of their role and role within the company. Trainings are needed to regularly inform people about plant- specific security measures, company cyber security policy and to prevent security gaps.

Figure 2: Defense in depth concept



Security requirements overview:

Implementing the necessary measures arising from cybersecurity- security plan inside a facility where many IACS are present can be a difficult task. Besides a holistic approach covering the entire facility, it is also important to define the detailed measures for each and every asset, including staff. The result is a set of procedures and measures that continuously and holistically monitor and protect the assets and production. Based on recommendations from NIST and the IEC organizations, it is required to apply a layered set off measures at all plant levels following a concept known as defense in depth. This provides a multi- faceted concept that gives your system both all- round and in- depth protection. The failure of a single measure will not cause the failure of the entire system. Before implementing any measure, a detailed risk analysis needs to be carried out in collaboration with the management of the company, IT and OT. The concept is based on plant security, network security and system integrity- according to the recommendations of ISA/IEC-62443, the leading standard for security in industrial automation.

Plant security:

Plant security uses several different methods to prevent unauthorized persons from gaining physical access two critical components. This starts with conventional building access and extends to securing sensitive areas by means of key cards. Comprehensive security monitoring leads to transparency with regard to the security status of production facilities. Thanks to continuous analysis and correlations of existing data and through comparison of these with threat indicators, security- relevant events can be detected and classified according to risk factors. On the basis and thorough regular status reports, plant owners receive an overview of the current security status of their production facilities, enabling them to react swiftly to threats.

Network security:

Network security means protecting automation networks from unauthorized access. This includes the monitoring of all interfaces such as the interface between office and plant networks or the remote maintenance access to the Internet. It can be accomplished by means of firewalls and, if applicable, by establishing a secured and protected industrial “Demilitarized Zone” (DMZ). The industrial DMZ is used for making data available to other networks without granting direct access to the automation network itself. The security- related segmentation of the plant network into individually protected automation cells minimizes risks and increases security. Cell division and device assignment are based on communication and protection requirements. To be protected from data espionage and manipulation, the data transmission must be encrypted via using a virtual private network (VPN), for example. The communication nodes are securely authenticated.

System Integrity:

The third pillar of defense in depth is the safeguarding of system integrity. Here, D emphasis is on protecting automation systems, control components, and communication components as well as Scada and HMI systems against unauthorized access turn on meeting special requirements such as know- how protection. Furthermore, system integrity also involves the authentication of users, access and change authorizations, and system hardening- in other words, the robustness of components against possible attacks.

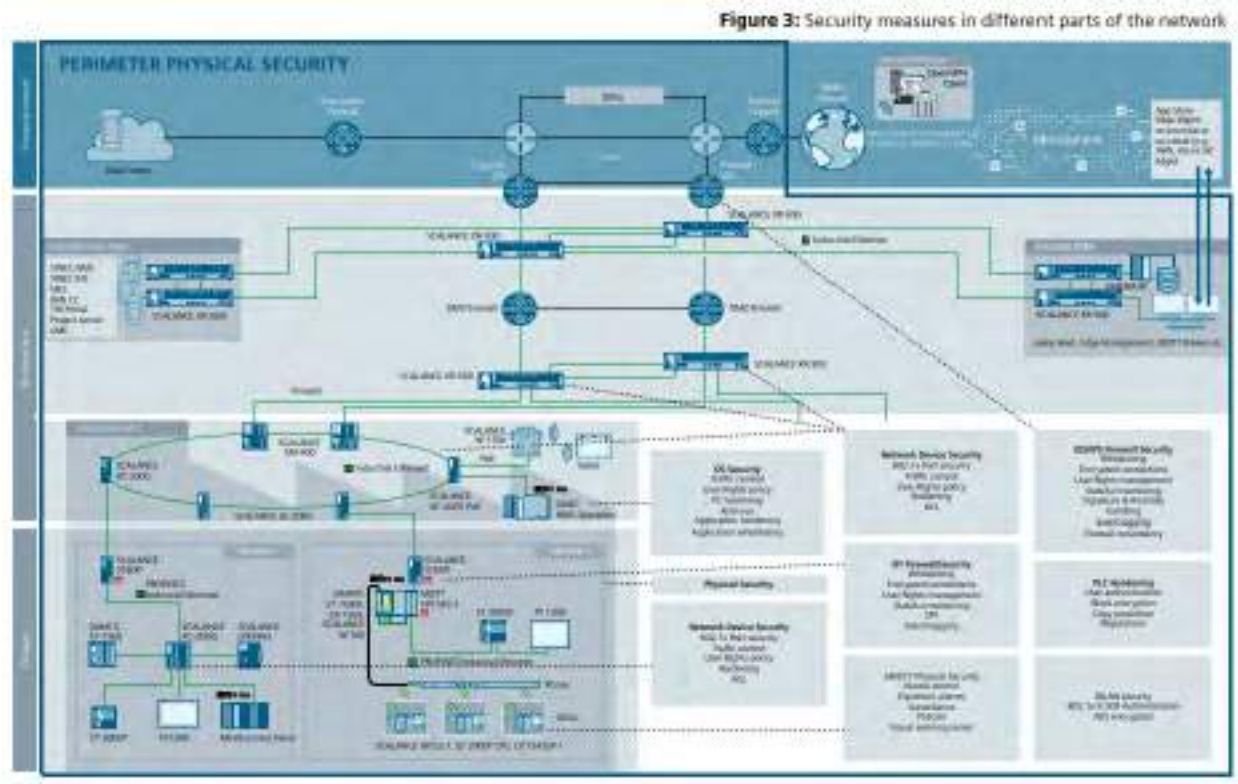


Figure 3: Security measures in different parts of the network

By: Vivek Roy – Head Digital Connectivity & Power at Siemens Digital Industries

"Boost your Cyber Resilience for Automotive & Medical IIoT Devices"

– Sivakumar Radhakrishnan, TÜV SÜD South Asia Pvt Ltd, Mumbai

ABSTRACT:

Digital technology and its transformation in Healthcare & Automotive Industrial internet of things – IIoT devices is of increasing relevance for both manufacturers & Service providers in their respective field. This technical paper is not a research paper but a sheer guidance to the industry end users based on the tangible ground realities, practically plausible and implementable solutions…

The wild growth of internet connected devices and their credibility for data transfer using wireless and other medians increase their vulnerability to cyberattacks. Hence, this paper attempts to review the cybersecurity threats to IIoT devices and possible corrective measures that can benefit Automotive & medical device manufacturers and service providers.

While, this paper tried to touch upon the direct & indirect cybersecurity threats to IIOT devices specific to Medical & Automotive sectors, major focus is given for the cyber resilience to IIoT in-line with the leading industrial standards and compliances for industrial cybersecurity…

Thus, this paper revolves around the cyber resilience to the cyber security threats & data privacy breach risks in IIoT devices specific to Medical and Automotive IIoT devices…

The future of Health care & Automotive IIoT devices are very much in the cloud, with more and more IIoT devices integrating with the internet of things, the author is confident that this technical paper would address the cyber security challenges the manufacturers & service providers now face and suggest the ways they can overcome the risks with full confidence and compliance to leading cybersecurity standards…

INTRODUCTION

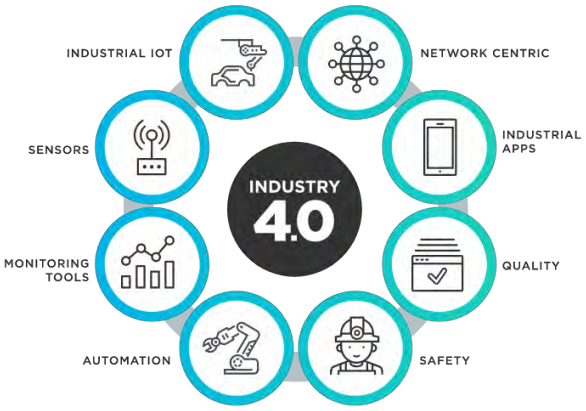
Major focus in this paper is given for the cyber resilience to **Industrial Internet of things – IIoT** in-line with the leading industrial standards and compliances for industrial cybersecurity… The wild growth of internet connected devices and their credibility for data transfer using wireless and other medians increase their vulnerability to cyberattacks.

Digital technology and its transformation in **Healthcare & Automotive** Industrial internet of things – IIoT devices is of increasing relevance for both manufacturers & Service providers in their respective field. Cybersecurity threats are increasingly more towards high critical industries like Automotive & medical device manufacturers and Health care providers.

Industrial Automation fraternity is more focused towards the cyber resilience to the **cyber security threats & data privacy** breach risks in IoT devices specific to Medical and Automotive IoT devices…

DRIVERS of IIoT

The IIoT market is expected to grow from USD 76.7 billion in 2021 to USD 106.1 billion by 2026, at a CAGR of 6.7% during the forecast period. Technology in demand is to bridge the process and operational efficiency in all discrete manufacturing which only IoT can do that. In specific, IoT will have a potential economic impact of up to $6.2 trillion by 2025 (ref: McKinsey survey)



With this, manufacturing to be the biggest IoT platform segment, reaching $438 million by 2021 and 20.8 billion connected things will be in use worldwide by 2020 (ref: Gartner)

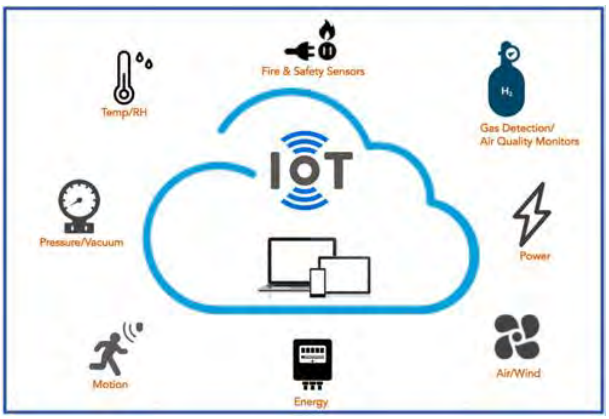
Another key driver is due to rapid adoption of artificial intelligence (AI) and internet of things (IoT) in the manufacturing sector. Also, due to the standardization of IPv6 (4% of the devices in the world use IPv6 protocol at present, while 96% of the devices still use IPv4 protocol) the growth is poised to reach new heights…

Industrial Automation Vs IIoT scope

The major growth and key scope among Industrial automation and IIOT would be in the following specifics,

- **Energy management/Optimization**
- **Predictive maintenance** - IIoT plays a leading role in creating an advance indication or alerts so that these operational and process incidents are avoided in a timely manner…
- **Operations** (Calibration & Alarms)
- **Asset tracking**

- Growing application of **AI and IoT** in medical sector during pandemic
- Rapid growth avenue of IoT & IIoT devices mostly dominates the **critical industries**, especially Medical & Automotive industries
- **industry 4.0 and medical technology** is in clear demand for connectivity for a faster decision in terms of machines & people…
- **Smart medical care & Smart automotive** are the integration of IIoT device side diagnostic/maintenance level to the end-user patient/passenger level…



Industrial IIoT – specific Risks

Due to the cybersecurity threats over both IT & OT critical infrastructure, this paper is more focused towards, key critical industrial verticals and in more specific to Industrial internet of medical things (IoMT) and Industrial internet of Vehicle things (IoVT)…

While these vulnerabilities can exist on any single device, the real danger is in connected things of medical & automotive sectors…

Specific cybersecurity risks in terms of cybersecurity threats, data security and data breach are applicable mostly to Medical device/health care industry and IIoT in automotive industry. These cybersecurity risks have made both the industries dangerously exposed to attack vectors/players on a daily basis which not only creates a huge financial loss, but also becoming a threat to human life & safety…

Smart medical care is becoming a key strategy for alleviating **operational and patient safety** at all level of its value chain…

IMPACT OF CYBERSECURITY IN IOMT

Medical records are very extremely valuable to hackers, in fact up to 10 times more valuable than a credit card details. But it isn't just data that cybersecurity experts fear may be at risk but the lives of the patients and health care providers are at risk due to ill-minded hackers…

It is evident that, if an **unauthorized access is gained to a medical device** or the patient's medical & personal records, there can be severe consequences. That is why it's crucial for cyber security risks to be considered both during the development and operational phase of the Medical IIoT devices.

Due to a **real-time data processing through medical devices and apps**, the future of medical devices and healthcare is very much up in the clouds. With more and more medical devices integrated with the Internet of Things, the healthcare business will be transformed towards automated & efficient service industry

Due to **digital revolution**, Medical Imaging Devices (MIDs), Pacemaker or any portable medical scanner face the greatest risk of cyberattack

CYBERSECURITY RISKS IN IIOMT

Following are the key cybersecurity risks in internet of medical things,

- **MIDs** will become blocked or disabled as part of ransomware campaigns
- **Tampering with parameter** values to alter radiation levels
- **Disrupting scan signals** to manipulate scans
- Denial-of-service **(DoS)** attacks that can prevent machines being used at all
- Updates on medical PCs & Exploitation of **outdated firmware**
- Drain battery life (**Firmware issue**)
- Allow **changes in programmed settings** (Firmware issue)
- **Change the beats and rhythm of the device** (Firmware issue)

CYBERSECURITY RISKS IN IOMT – DATA SECURITY

Like the cybersecurity risks on device, application & cloud related to IoT devices, another key threat is related to data security and data privacy in IoT devices…

The collection of data through devices and apps will enable **real-time access to more patient data** than ever before. **Digital access to patient records** give rise to new dimensions of risks related to Data security & Data privacy breach.

Cybersecurity risks related to data breach in patient medical history/MIS/database where the risk is related to Patient data privacy…

Another key treat is on indirect disruption of digital patient records

IMPACT OF CYBERSECURITY IN IOVT

Cybersecurity has a greater impact on automotive sectors especially in passenger cars and other vehicles… growth is usually observed on multi-fold in **Modern telematics systems** and sensors guide drivers as it enables the safe negotiation of the road conditions which is quite popular…

Another popular growth area is on the **wireless communication systems** which enables all type of interaction with nearby peers to relay safety critical metrics and alerts. New technologies such as **Artificial Intelligence and its subset**, Machine Learning, Computer Vision, IoT, Cloud Technologies are nurturing innovation in the connected vehicles industry.

The key benefits pursued are improvements **in overall safety** (through driving assistance, crash avoidance systems and overall reduced human error), higher vehicle reliability with devices fitted with **onboard diagnostic systems (OBD),** better human-machine integration using speech recognition and operational improvements including reduced traffic congestion, optimized freight flow and traffic control, etc.

Apart from this, IoT plays a major role in **remote operations like locking, unlocking and ignition controls** using mobile phone applications…

CYBERSECURITY RISKS IN IOVT

Following are the key cybersecurity risks in automotive sectors,

- Connection risks
- Manipulation of safety-critical systems
- Mobile application security vulnerabilities
- Security vulnerabilities in the complex supply chain
- Failure to keep up with the latest security patches and updates
- Inadequate key management processes (manual cryptographic keys)
- Theft of personal data
- In Vehicle Infotainment (IVI) vulnerabilities

Mandate for Medical / Health / Automotive Industry

Apart from the tackling the threat actors and vectors, there are key international standards and compliance requirements related to medical & automotive sectors… few of the key requirements are listed below,

- VAPT testing for HIPAA Compliance
- VAPT testing for NIST Compliance
- Medical Device Security Testing Equipment
- Medical Device APP Testing
- Health Industry APP, CLOUD & DEVICE Testing
- Network Infra Testing for Medical/Device Industry

Cybersecurity Mandate for Medical / Health / Automotive Industry

- Penetration testing to Comply HIPAA (Std § 164.308(a)(8) and NIST 800-66 requirements)

- Mandatory GDPR (EU) 2016/679 (DPIA assessment – WP 35 and WP 29 Guidelines)

Cyber Security Testing & Data Security Assessments

Following are the key cybersecurity testing strategies aimed for **IoMT** and **IoVT** sectors,

- Comprehensive vulnerability assessment and penetration testing of IIoT/IOMT device
- Test should focus on mobile application, cloud APIs, communication and protocols, and embedded hardware and firmware.
- Identify the potential vulnerabilities that could be exploited which in turn impact the business continuity & safety.
- Secure IIoT / IoMT device & systems from Cyber Threats and Provide the recommendations as per industry best practices

Picture Courtesy: Elyan Labs

Data Security & Data privacy assessments for your IoMT & IoVT

Following are the key data security and data privacy assessment strategies aimed for IoMT and IoVT sectors,

- **Periodic assessments** are now being mandated for IoMT & IoVT systems that are often pose risk to users' privacy via disclosure of personal information to third parties
- The General Data Protection Regulation **(GDPR)** assessments should be done to ensure protection of personal data, fair processing of data, and in line with the Compliance

- Data Privacy Impact Assessment **(DPIA)** should be carried out for IoMT & IoVT to ensure the sensors do not collect any more data than is necessary for fulfilling the relevant commercial purpose (information can no longer be traced back to individual persons)

Focused testing approach for IoMT / IoVT

Activity	Description
What & How	a. In this phase we try to get familiar with the understanding of product b. This includes technical walkthrough of the application from client c. Identifying the technologies and their key functionalities in the product
Mapping attack surface & targeting	a. The modes of communication [**Wired** - WIFI, ZigBee, Bluetooth, etc. & **Wireless** – Serial communication, USB, sensors, etc.] b. Web/cloud interfaces c. Mobile/Desktop application d. Analyzing Firmware
Penetration testing	Performing targeted attacks on the identified attack surface
Reporting	Providing description of identified vulnerabilities and remediation
Revalidation	Rechecking the fixed issues

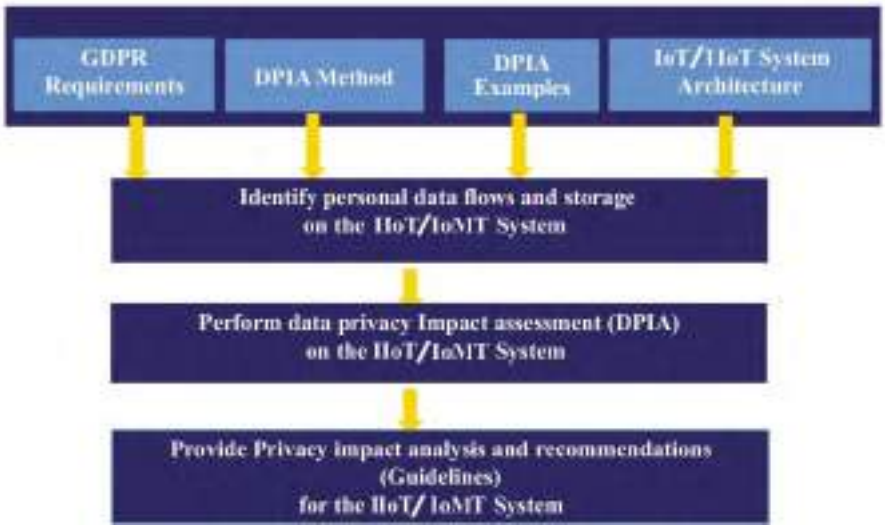
Recommended Testing Methodology (IoT OWASP Top 10)

Activities	Scope	Deliverables
1) Grey Box Web Application Security Testing	• URLs	✓ Greybox Penetration Testing Report
2) Mobile Application Security Testing	• iOS • Android	✓ Mobile Application Security Testing Report
3) Network Vulnerability Assessment and Penetration Testing	• Endpoints	✓ Network Vulnerability Assessment & Penetration Testing Report

Category	Description
Weak, Guessable, or Hardcoded Passwords	Use of easily bruteforce, publicly available, or unchangeable credentials, including backdoors in firmware or client software that grants unauthorized access to deployed systems.
Insecure Network Services	Unneeded or insecure network services running on the device itself, especially those exposed to the internet, that compromise the confidentiality, integrity/authenticity, or availability of information or allow unauthorized remote control.
Insecure Ecosystem Interfaces	Insecure web, backend API, cloud, or mobile interfaces in the ecosystem outside of the device that allows compromise of the device or its related components. Common issues include a lack of authentication/authorization, lacking or weak encryption, and a lack of input and output filtering.

Lack of Secure Update Mechanism	Lack of ability to securely update the device. This includes lack of firmware validation on device, lack of secure delivery (un-encrypted in transit), lack of anti-rollback mechanisms, and lack of notifications of security changes due to updates.
Use of Insecure or Outdated Components	Use of deprecated or insecure software components/libraries that could allow the device to be compromised. This includes insecure customization of operating system platforms, and the use of third-party software or hardware components from a compromised supply chain
Insufficient Privacy Protection	User's personal information stored on the device or in the ecosystem that is used insecurely, improperly, or without permission.
Insecure Data Transfer and Storage	Lack of encryption or access control of sensitive data anywhere within the ecosystem, including at rest, in transit, or during processing
Lack of Device Management	Lack of security support on devices deployed in production, including asset management, update management, secure decommissioning, systems monitoring, and response capabilities.
Insecure Default Settings	Devices or systems shipped with insecure default settings or lack the ability to make the system more secure by restricting operators from modifying configurations.
Lack of Physical Hardening	Lack of physical hardening measures, allowing potential attackers to gain sensitive information that can help in a future remote attack or take local control of the device.

Data privacy & DPIA Assessment IoMT / IoVT

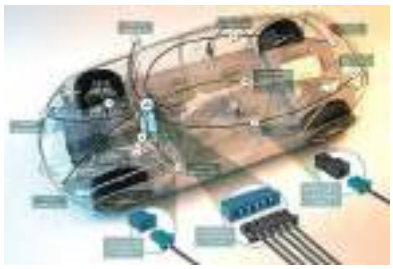


Guidelines for GDPR & DPIA Assessment on IoMT / IoVT devices

- Privacy notice on the company website
- Information security policy
- Asset management & data classification policy
- Access control policy
- Cryptography policy
- Incident management policy
- DPO roles & responsibilities document
- Data subject's rights procedure
- Data retention & deletion procedure
- International data transfer procedure
- Consent management
- GDPR awareness for employees
- Security/vulnerability assessment reports for the products
- Data flow diagram for all departments (source of data, processing and storage of data and how data is deleted)
- Product architecture & data flow diagram.
- Product manual in the English language.
- Privacy policy embedded in the products for the end-user

Key Coverage – Cybersecurity Services for IIoMT Sector

SCOPE COVERAGE – Connected IoVT Devices



GDPR (DPIA) for T-Box in Passenger Cars

CONCLUSION

As digitalization increases in IoT devices, software, hardware & application vulnerabilities will also increase…

Until all the strict coordination and implementation of IoT related cybersecurity standards & compliances become a part of basic IoT requirements, secured IoT solution will remain poor…

Cooperation and collaboration between vendors and the manufacturers of IoMT & IoVT is essential for a secure future IoT, and there is **no shortcut to guarantee of success**…

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Making Digitalization Work for you!
Approach for Implementation

Amit K Aglave, Pragati Agrawal

Fluor Daniel India Pvt. Ltd.

ABSTRACT

Digitalization and Industry 4.0 is said to set the industry in to next step of journey to improvise the efficiency in operation and increase profitability. As organizations embarks onto this Digital Transformation journey, the success of implementation and achievement of intended results depends mostly on the strategic approach for the digitization.

Such an approach shall include clear target setting that is both, practical to achieve and easy to realize the benefits. This includes optimization of a process, improvise efficiency, and reduce unplanned events and outage. Leveraging emerging technologies, data analytics and contemporary solutions, it's possible to achieve Digitalization targets.

This paper provides critical factors such as improved Return on Investment (ROI), enhanced management dashboards, asset management, optimized supply chain, cyber security, knowledge management, and skill development for which Digitalization and Industry 4.0 can be conceptualized.

KEYWORDS

Industry 4.0, Digitalization, IIoT, AI/ML, Drones, Digital Twin, RPA, Cyber Security.

BACKGROUND

The limitless imaginative power of the human being unleashes strong desire to do things in a better, and efficient manner. The pace of change in technology compared to the earlier era of industrial revolution is comparable to the blink of eye. The main drivers for this rapid change can be attributed to the developments in the tools for automation, information technology and huge computing power to churn out large amount of data in shortest amount of time for analytics. Conventionally, the process industry, has been cautious in adopting latest technology, especially in the Operation Technology (OT) environment due to protective approach with respect to continued operation, uninterrupted production, and process safety targets. Over past couple of years, the buzz around the Digitalization and Industry 4.0 is growing rapidly and there is a sense of unease in the business owners on missing digital transformation and left behind the competition. The competitive market scenario and deemed benefits in operational cost (OPEX) reduction are driving the potential investments.

However, implementation without having a vision of what is to be achieved by adopting to the latest technology may result into distrust in

the stakeholders and investors and leave the potential of the Digitalization and Industry 4.0 unexplored.

DIGITALIZATION & INDUSTRY4.0

The terms commonly used today are Digitalization and Industry 4.0. Understanding these in detail, a review of present-day methods on how an activity or task is performed and understanding where improvements can be done will help create the vision for what your organization need to transform and achieve.

Digitalization involves changing a manual process or workflow into digital process by use of digital technology. Digitalization brings in efficiency to the manual processes. A change of the way the plant shift operators updates the shift log, handover the shift to next operator with use of digital technology is one of the examples of Digitalization. Another example is data captured by field operator in field rounds from a sensor barcoded with its detail and entering the data on handheld device for storing on central database repository.

Industry 4.0 refers to fourth industrial revolution which makes use of Digitalization-based technologies such as use of IIoT (Industrial Internet of Things) sensors, cloud computing, artificial intelligence, machine learning, Big Data for analytics, digital twins etc. These technologies are applied to achieve better efficiency, aid decision making for sustained operations, create an integrated high level operational condition of the facility and most importantly, improve profitability.

Effective implementation of Digitalization / Industry 4.0 highly depends on the extent of data and quality of data from the plant. The intent of application of Digitalization technologies is to gather, analyze and covert data for enhanced user experience and savings.

It is important to understand the present state of the process industry with respect to the implementation of Operational Technology (OT) and Information Technology (IT) to analyze the need for implementation of newer technologies.

PROCESS INDUSTRY – PRESENT STATE OF SOLLUTIONS – OPERATIONAL TECHNOLOGY

The process industry has seen rapid change over last five decades in a way the plant is monitored and controlled. Moving from hydraulic, pneumatic controls, and relay-based controls to single loop controllers to Programmable Logic Controllers (PLC) and Distributed Control System (DCS) and computer-based data storage and display opened opportunities for optimization and efficiency in process operations. These systems, often termed as plant automation systems are the brain of the process plant. There are several dedicated systems for special applications such as vibration monitoring, anti-surge system, governor control systems etc. which are implemented for protection of critical machinery as well as maintenance of the systems.

Implementing applications such as alarm management, asset management, historian have become a norm. The alarm management systems not only alert the operators to investigate critical condition of a process parameter, but also guide operators on pro-active actions that are to be taken to avoid an abnormal plant condition. The asset management systems help perform the maintenance activities in timely manner. The historian is used for analyzing important historical conditions of the plant such as trips, process excursions from the normal range, and provides history of all actions taken by the operators etc.

Over two decades, wireless monitoring has opened new dimension of plant condition monitoring. The areas that could not be

monitored earlier or monitored manually at a longer frequency are possible to be monitored remotely today with the help of several wireless technologies. Remote tank levels, steam traps, pressure safety relief valves, non-critical battery limit monitoring are some of the examples of such remote monitoring.

Closed-Circuit Television (CCTV) cameras are implemented at strategic locations to aid the operators with the key visuals from the plant area.

There are other multiple specialized applications which are not doing mission critical process control applications but gather important aspects of the plant status and operating condition. These include the Mass and Energy Balance, Continuous Emission Monitoring System (CEMS), Laboratory Information Management System (LIMS), Tank Farm Management System (TFMS), Terminal Automation System (TAS), Oil Movement and Storage (OM&S), Machine Condition Monitoring System (MCMS) etc.

PROCESS INDUSTRY – PRESENT STATE OF SOLLUTIONS – INFORMATION TECHNOLOGY

The present IT solutions implemented in process industry are mainly focused on managing business process workflow with applications such as Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES). These systems are implemented to manage the aspects of planning raw material, inventory management, production planning and scheduling, maintenance etc. apart from many other aspects.

While the OT platforms automate the process, make it safe and reliable, IT platforms make it more efficient and coordinated.

PROCESS INDUSTRY – TAKING IT TO FUTURE – IT/OT INTEGRATION

Industry 4.0 envisages an amalgamation of IT and OT platforms where the processes with the power of internet provide aids end user in better decision making and effective control of the operations and maintenance.

The integration of IT/OT or commonly known as IT/OT convergence is necessary to improvise the business processes. The IT/OT integration requires pulling data from different silos. The present trend is to have the IT/OT convergence through the data historian. As there is huge data generated from the IT as well OT systems, filtering of relevant data and forming a Data Bank or Big Data for further use is the first step in the Digitalization implementation strategy. The data from automation systems and other special application systems is integrated to perform asset performance analysis, improvise efficiency as well as maintenance planning.

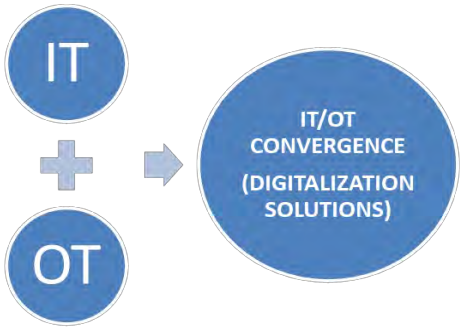

FIGURE 1. IT/OT CONVERGENCE

This integration requires experienced resources, coordination and collaboration with different vendors and organizations. The newer solutions include implementation of solutions in a manner that this integration is optimized. Approach should be to utilize as many existing systems as possible to minimize efforts and avoid expensive upgrades. Understanding the protocols of the IT/OT systems, how to develop the network architecture, how to exchange data, how to implement cyber security, and how to

secure the process automation systems are some of the key points to be considered.

With the IT/OT integration, there are number of Industry 4.0 solutions which are available and contribute collection of data about plant operations, visualize and represent in management dashboards for better decision making. The data gathered is analyzed in real time and not only to provide information to users, but also to utilize in various applications such as predictive modelling to improve yields, achieve energy efficiency, plan maintenance, improvise workflow process etc.

NECESSITY OR COMPULSION

There are several companies offering solutions in the Industry 4.0 arena attempting to add value to the customers. However, there are some campaigners who instill fear of being left out, fear of margin erosion or fear on how disruptions in the demand are seen due to alternates. Further, there is competition which you hear who are implementing variety of solutions and then there is a catch-up story. Rather than going for implementation of solutions based on such notions, look out for a partner who shall be in consultative mode and weigh all the deemed benefits before proceeding. A holistic approach should be taken rather than piecemeal approach to ensure a need-based adaptation of the technology is done yielding maximum benefits. This will avoid being trapped into a vicious cycle of implementation.

The main drivers for proceeding with Digitalization / Industry 4.0 are:

- Improvement in efficiency
- Faster reach to market
- Flexibility in manufacturing and maximizing throughput
- Improvement in production quality
- Improvement in business processes

VISION FOR IMPLEMENTATION

Since the implementation of Digitalization and Industry 4.0 consists of various Digitalization-based technologies, what technology to apply, what are the expected benefits, what will be the stage when a particular technology will be applied, what will be the cycle of the implementation, what resources would be required are some of the key aspects to be considered. Taking all the facts and figures in account, a vision for the implementation to be developed. Implementation can be staggered, but the vision for the implementation should be clear. This vision can be then converted into a roadmap and actionable items at each stage of the implementation journey, for example as shown in figure 2.

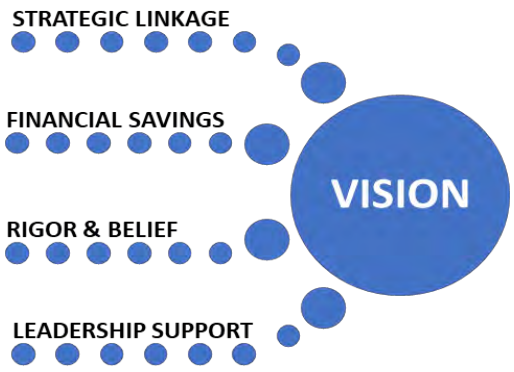

FIGURE 2. INDUSTRY 4.0 VISION

Developing the vision requires some key points to be identified:

- **Strategic linkage** – Identifying the strategic linkages in the data gathered from different systems and transforming the unstructured data for practical use in various applications.
- **Financial savings** – The financial savings to be achieved should be a key factor in defining the vision. Without any financial savings, support from the top management can easily fade out.
- **Rigor and belief in Industry 4.0** – The fear of unknown, misconceptions about the challenges in implementation and challenges faced in past in implementation of plethora of solutions can raise doubts on decision making.

However, putting a structure around implementation, choosing right partners, and developing people with required skills will help overcome this disbelief.

- **Strong review mechanism** – Routine and regular review on the progress of implementation will help understand if the intended objectives are being met and if any corrections are required if deviations observed.
- **Leadership support** – Its vital that the key decision makers are fully appraised of all planned and developments along the course of implementation so that a sustained support in terms of funding and resources is available.

WHY ADAPT – IDENTIFYING OPPORTUNITIES

Digitalization has huge benefits, but the implementing company need to identify the areas where this implementation would bring favorable results. On a broader level, the expectations post application of the Digitalization and Industry 4.0 technologies is to achieve operational efficiency, energy efficiency, optimized utilization of the scarce resources, betterment in maintenance strategies which contribute to the overall profitability.

Further, it is also expected that these technologies will assist in better inventory management, production planning.

It is also expected that the implementation would help create simpler and effective dashboards for the decision makers with data such as plant efficiency, product planning, resource allocation etc.

A key factor on identifying the opportunities for implementation is distinguishing between the core and peripherals of the process.

For the existing plants, changing the core would not only be a mammoth task, but the results might be miniscule. The changes around periphery are comparatively easier and can be done at most of the times without disrupting the production. For new projects, the implementation can be planned from beginning which maximizes the implementation around core as well as peripherals. For example, during engineering stage, the EPC (Engineering, Procurement, Construction) contractor use various tools for engineering, modelling, simulation, scheduling, tracking, material management, project management, cost management etc. This data can be utilized as the basis for the digital strategy in the operational phase of the plant. Planning for the integration of this data, operational data of the process, workflow processes, maintenance related data from equipment and machinery must be mapped to achieve the Digitalization goals.

IMPLEMENTATATION STRATEGY

The implementation strategy should be developed based on the vision statement. As there are different solutions available under the umbrella of Industry 4.0, selecting one or more of these for implementation, assigning resources for implementation, selection of appropriate products and solution provider, if necessary, re-calibrating requirements based on the changing arena are some of the key factors to be considered.

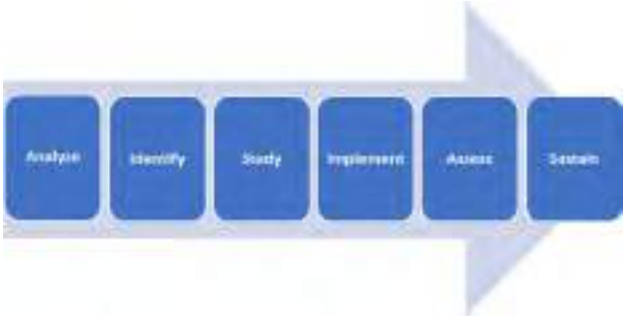

FIGURE 3. IMPLEMENTATION STRATEGY

The major steps in implementation are:

- **Analyzing present state of operations** – Review of existing IT, OT, business processes, manpower allocation and performance parameters.

- **Identification of opportunities** – Benchmark with the company/national or international standards, estimate expected returns and apply one or more available Digitalization technology.
- **Commercial feasibility study** – A cost benefit analysis should be performed before proceeding with investment. Important aspect of return on investment (ROI), payback period should be calculated.
- **Plan and implement** – Identify resources, plan on how the implementation would happen and execution of implementation and the milestone dates for achieving various aspects of implementation. The planning should also include a risk management plan for understanding the risks and what are the mitigation actions to be taken if the risk is realized.
- **Assessment and improvements** – Post implementation, assessment should be done to verify the targets are met and if any further improvements are necessary.
- **Sustain** – Sustain and maintain the implemented technology throughout its lifecycle.

The building blocks for the implementation of the overall solution includes are depicted in the figure 4.

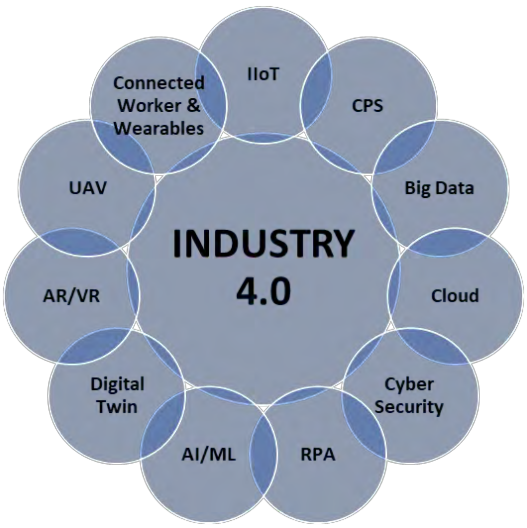

FIGURE 4. INDUSTRY 4.0 BUILDING BLOCKS

INDUSTRIAL INTERNET of THINGS(IIoT)

Internet is now commonly used by most of the personnel around the world for different applications. This usage is called internet of people. When internet is used for connecting things (objects, machine etc), its termed as Internet of Things (IoT). The industrial application of IoT is termed as IIoT. The use of sensors, actuators with capability of communications built into physical objects is done for capturing data into computer-based systems. This data is used for either in one or more applications or used for analysis.

The analysis which can be a real-time analysis, interactive analysis, predictive analysis, or batch analysis. The suitable actions are taken on the information from the data by sending either alerts, generating queries, providing visual information on operational state or to take control actions. Use of one of the protocols such as ISA 100, Wireless HART, RFID, Bluetooth is done to transfer the data with the use of communication devices such as WIFI, Ethernet, ZigBee etc. based on the distance where the data is to be passed.

Though the process automation systems are serving similar objectives, the data captured resides within the process automation systems and not passed to the common repository such as cloud for use by more than one application. If required for use in other applications, the data must be specifically configured to be passed to other applications.

There are numerous IIoT based applications being implemented in the process industry where the monitoring was not done earlier owning to higher cost. Application of sensing to steam traps and relief valve leakage are some of the examples already being deployed.

Though the data from these sensors is still passed to process automation systems, a shift towards use of the IIoT sensors directly connected to cloud computing will increase in coming years.

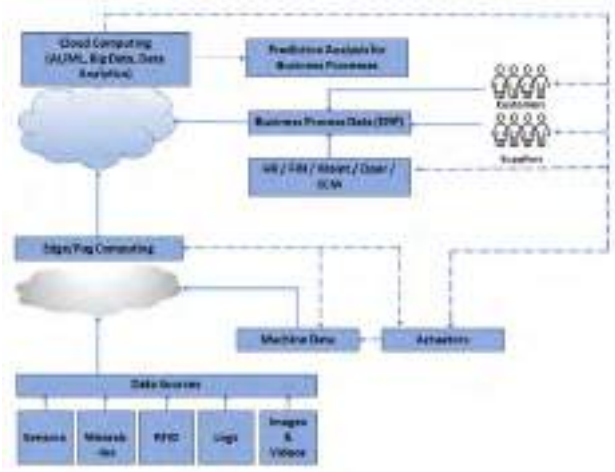

FIGURE 5. INDUSTRY 4.0 BASIC ARCHITECTURE

Additional monitoring points from non-critical machinery and equipment are being added to enhance the plant health check. This includes vibration and temperature monitoring of the rotating machines where data is passed through edge computers to cloud.

CYBER PHYSICAL SYSTEMS (CPS)

CPS are engineered systems having computing, communication, and control capabilities. CPS is generalization of embedded system that interacts with the physical world with sensors and actuators. The digital technologies and application of CPS include automatic decision-making systems.

BIG DATA and DATA ANALYTICS

Big Data in the simplest term is data which is large amount. In process industry context, the Big Data is generated from the IT/OT and available for further processing.

The data collected can be either structured or unstructured data. The important aspects of the data to be understood are classified in 5V's which are the '*Volume'* of the data, '*Variety'* of the data, '*Velocity'* of the data, '*Value'* of the data and '*Veracity'* of the data.

The use of the data in different business process to being in improvements is achieved by performing data analytics. This is done by data mining tasks such as data classification, data association, data clustering, understanding sequential pattern, detection of deviation and visualization.

Some of the use case examples of the Big Data is use in applications developed for predictive maintenance, machine learning, achieving operation efficiency.

CLOUD COMPUTING

Cloud computing is accessing through internet, IT resources and services which includes applications, server, data storage, networking, applications, analytics hosted at a data center by third party cloud service provider. The benefit of this is the user doesn't have to worry about obsolesce in the computer infrastructure, software versions etc. and can optimize the IT resources across their geographically spread facilities. Centralizing the data on the cloud opens possibilities of multiple applications such as data analytics, AI/ML, digital twin to name a few.

ARTIFICIAL INTELLIGENCE and MACHINE LEARNING (AI/ML)

Artificial intelligence is creation of software capable of making intuitive decisions. Machine learning is subset of AI which empowers the machines to take decisions based on the experience rather than being explicitly programmed for taking these decisions. AI/ML has

developed over last half century from using simple algorithms, to neural networks to present day deep learning.

Machine Condition Monitoring System is an example where AI/ML is already applied to predict the maintenance requirements on critical machinery.

Digital twin is one of the application areas of AI and the use of digital twin will rise exponentially in coming years. Addition of IIoT sensors to the plan and gathering of large data and strong data analytics will pave in new applications for the critical infrastructure maintenance.

DIGITAL TWIN

Digital Twin is creating digital replica of equipment or a process plant, i.e., a physical asset. Digital twins are based on steady state simulation or dynamic simulation and can run advance process control and multivariable predictive algorithms. Digital twin helps with insight of the design and modifying it if required before the building the physical asset. It also helps better understand the requirements of transient conditions such as start-up and shutdown, process behavior on disturbances. Further, the digital twins in operational plant can help achieve optimization, identify potentially hazardous conditions, and help with predicting maintenance requirements.

Important aspect of digital twin is understanding of the domain knowledge and industry experience.

ROBOTIC PROCESS AUTOMATION (RPA)

RPA (sometimes referred as BOTS) is automation of the manual work processes which are performed by humans daily and are repetitive in nature. It is software-based and implemented to work in same manner as humans. RPA is applied to automate process which are highly manual and repetitive or rule-based processes. RPA is more suited for IT applications, but a hard look into possibilities where it can be applied to OT needs to be investigated.

AUGMENTED / VIRTUAL REALITY

Augmented reality is enhanced version of reality and provides direct or indirect views of physical world environments in augmented form with computer generated superimposed images. It adds digital elements to their actual environment and amplifies the present perception of reality.

Virtual reality is mix if interactive hardware and software based artificial environment to form a realistic three-dimensional image is created and presented to user in such a way that they normally interact with physical world.

Training to the operators and maintenance enhancement are some of the applications of AR/VR in the process industry.

In engineering phase, AR/VR can be applied to enhance the user experience by simulation during model reviews. This will help the reviews with better visualization and checking conformance to the specification requirements.

CYBER RESILIENCE

Cyber resilience is an important aspect of digital transformation journey. As the OT systems are mission-critical for people and process safety as well as for safer operations, any cyber-attack can lead to incidents of devastating scale, off-spec production. The IT systems carry lot of confidential information which the attackers can access and either sell in market or manipulate to

create business disruptions. With ever growing risk and new methods devised by the attackers, the data vulnerability either within the plant infrastructure or on cloud platforms can be detrimental. There are numerous cyber-attacks targeted and succeeded on the industrial operations and manufacturing plants in recent past. The cyber threats are real, and implementation of cyber security should not be considered as one time activity. Timely updates of the software based on recommendation from the OEM provider, multi-level user authentication, increasing awareness in the users and enforcement of policies and procedures are some of the key points to be considered.

The cyber security should protect against unauthorized changes in the data and unauthorized access to the systems.

CONNECTED WORKER & WEARABLES

The use of the digital technology is applied with use of mobile devices to ease the field operator jobs such as operator rounds, workflow process guide, capturing the videos of the inspection and ensures operator safety.

The wearables include connected cameras which are mounted on the hat and handsfree speakers for remote assistance from control room or outside plant from an expert who can be located anywhere on the globe. The wearables also include identify location of the operators which can be useful in assigning tasks, emergency response and evacuation.

Fluor has used wearables in some of the projects and results were impressive. Subject Matter Experts connected to the site workers to troubleshoot the problems right away as the COVID 19 pandemic resulted in severe travel restrictions. The images captured from the expert guidance are now available for further reference if similar problems recur.

UNMANNED AERIAL VHICLES (UAV)

Use of UAVs or drones is becoming common for various applications. In process industry too, use of drones is becoming common. Drones can be used for surveillance, monitoring the areas which were normally inaccessible such as flare tops, internal monitoring of the linings of the flares (un-operational condition) and pipelines, as sensor for capturing various data from the plant such as hot spots. Further, the data captured can be part of Big Data where the data is used for analysis as required.

Drones are used by Fluor for Virtual site walk, flare inspection with an infrared camera, inspecting inside equipment areas and gather site information through aerial imagery. Additional envisaged usage of drones includes delivery of critical small components at work front, capturing real time site images to overlay on models / simulations etc.

ADDITIVE MANUFACTURING / 3D PRINTING

As per ASTM, 2021, additive manufacturing is process of joining materials to make objects form 3D model data, usually layer upon layer as opposed to subtractive manufacturing methods. Additive manufacturing or 3D printing enables rapid prototyping and free form fabrication or manufacturing of complex components in one go without assembly.

For last one decade, 3D printing has got a wider contemplation for industrial purposes. The key features of this technology are prototyping, repeatability and precision. The 3D printing can be applied to wide range of materials

including metals. The use case of 3D printers at NASA, when an astronaut at International Space Station could 3D print from a CAD file of the tool is most referred example.

The possibility of 3D printing has opened newer dimensions to the way requirements can be managed in urgent and critical situations, especially for remote and inaccessible sites.

PREVENTIVE MAINTENANCE & ANALYTICS

Health of in-service equipment and machinery is monitored through data from internet-based sensors and prediction engines provides early warning of possible asset failures or malfunctions. The user receives alerts for taking proactive actions to avoid disruption to the operations.

The use case example is application of IIoT sensors and edge computers to monitor the health of heavy equipment like air compressors or power transformers. Data from these sensors i.e., heat, vibration, oil level etc. is captured, modelled, and analyzed to preempt upcoming maintenance requirements or probable breakdown of equipment.

RADIO FREQUENCY IDENTIFICATION (RFID)

Use of RFID has brought transformation in supply chain, warehouse, and inventory management. RFIDs can be configured with data of the object on which it is placed upon and the RFIDs can be scanned even if it is placed inside a box.

RFID combined with GPS (Global Positioning System) enables efficient and detailed tracking of material. In warehouses, RFID tags can optimize the inventory to a great extent with smart shelves. Fluor has used RFID tags in one of our projects for spools, instrument tags, cable drums etc. The implementation has saved on supply chain man hours, advanced the tracking mechanism and effective warehousing reduced the lost items substantially. The possibility of retaining the RFIDs with configured data on critical instruments and equipment when in operations is a possible scenario for consideration.

CHALLENGES

TIMING of IMPLEMENTATION

A key decision to be taken for new projects for implementation of the Digitalization and Industry 4.0 is the timing. Implementation during the project stage has additional burden on the cost of the project. The benefits however of starting early is the work processes are adapted from beginning rather than requiring mindset shift. Any adjustments during operations can be suitably adjusted. For operational plants, getting data from existing systems, adding more data points are to be investigated. However, the business processed are normally well set.

SOLUTIONS

A plethora of solutions are available. Rather than applying multiple applications, look at the possibility of a solution which can address multiple challenges but is not too complex to implement and maintain.

CYBERSECURITY

The process control systems have seen rise in the cyber-attacks and attempts. The nature how the control systems are designed now a days and further implementation of Industry 4.0 makes it more susceptible to the threats. However, rather than shying away from

implementation of Industry 4.0, a robust cyber security implementation strategy should be in place.

RESOURCES

The availability of the resources with the process domain and Industry 4.0 understanding are rare. Investments should be planned on hiring resources as well as training of the employees.

STANDARDS & COMPLIANCE

There are no specific standards and regulatory requirements available so far which will guide on the baseline requirements and factors which should be considered while deploying the Industry 4.0 Digitalization solutions.

MATURITY ASSESSMENT

An independent maturity assessment of the implementation to check the achievement against the targets should be planned. This will help address the shortcomings. The Industry 4.0 maturity assessment consists of review of three aspects:

FIGURE 6. INDUSTRY 4.0 MATURITY ASSESSMENT

- **Voice of Technology** – Assessment carried out in context of the implemented Industry 4.0 technology such as IIoT, AI/ML, AR/VR etc.
- **Voice of Business** – Assessment carried out in context of the business scenario of the plant. This assessment helps business excellence with the help of projects to improve the bottom line and top line of the company.
- **Organizational Context** – Assessment carried out in context of the leadership and various departments such as operations, supply chain, human resources, technology etc.

The result of the assessment shall help understand the Industry 4.0 maturity score and help on identifying the improvement projects to be taken up.

BENEFITS

The benefits of the implementation of the Digitalization / Industry 4.0 can be in the form of CAPEX benefits or OPEX benefits.

CAPEX Benefits

- Replication & reuse
- Reduce leakages in information handover

OPEX Benefits

- Improved process safety
- Improved Reliability
- Real-time availability of information
- Predictive Maintenance
- Better understanding of demand
- Efficient supply chain
- Sustainable operations with better profitability

Dashboards

- Pre-configured and on demand dashboards to indicate state of operations
- Management dashboards for making business decisions

- Dashboards for different use by operations, maintenance for efficient execution of tasks

CONCLUSION

The OT has been addressing many aspects of the Digitalization, though in form of separate and unintegrated applications. Thus, the OT has been an enabler and a step towards the Digitalization. The plant automation systems and sensors have enabled large amount of data being available and the case for the Digitalization and industry 4.0 can be built upon this.

The pace at which OT moves is slower due to the inherent requirement of the business, i.e., continued production for achieving faster return on huge investments made and ensuring safer operations.

The IT systems are more versatile, adaptable, and fast paced when it comes to deployment of the solutions. The developments in the IT arena can be used as an enabler for bringing in digital transformation to the OT systems.

Breaking out from the silos of IT and OT, deployment of the technologies under the umbrella of Industry 4.0 is set to become new norm as organizations adapt to the convergence. Over period, it will become the way an organization operates.

Setting an unbiased vision for Digitalization implementation, allocating right resources, leadership support, and regular assessment on the maturity is the way to –
'***Make Digitalization Work for you***'!

ACRONYMS

AI	Artificial Intelligence
CCTV	Closed-Circuit Television
CEMS	Continuous Emission Monitoring System
CPS	Cyber Physical Systems
DCS	Distributed Control System
EPC	Engineering, Procurement, Construction
ERP	Enterprise Resource Planning
GPS	Global Positioning System
HART	Highway Addressable Remote Transducer
IIoT	Industrial Internet of Things
ISA	International Society of Automation
IT	Information Technology
LIMS	Laboratory Information Management System
MCMS	Machine Condition Monitoring System
MES	Manufacturing Execution Systems
ML	Machine Learning
OM&S	Oil Movement and Storage
OT	Operation Technology
PLC	Programmable Logic Controller
RFID	Radio-Frequency Identification
ROI	Return on Investment
RPA	Robotic Process Automation
TAS	Terminal Automation System
TFMS	Tank Farm Management System

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ACKNOWLEDGEMENTS

We would like to thank Shankar Vaidyanathan, Senior Fellow, Fluor Houston for his support, motivation, and vision for the Digitalization subject.

We would also like to thank Jagannadh Vadlamani, Senior Analyst – OT Security, ADNOC for his support and guidance in completion of this paper.

We would also like to thank Fluor New Delhi senior management for encouraging us to pursue writing of this paper.

BIOGRAPHY

Amit is a graduate in Instrumentation engineering. He has 25 years of experience in process industry and specializes in the design and engineering of Safety Instrumented Systems (SIS) according to the functional safety standards of International Electrotechnical Commission (IEC) 61508/IEC 61511.

He is certified Functional Safety Expert and certified Industry 4.0 Assessor.

Pragati is a Supply Chain professional with 14 + years of industrial experience across various portfolios in process industry. She's an MBA in Strategy and Marketing and Instrumentation engineer by qualification. She is working with Fluor Daniel India Private Limited as Global Category Manager for Instrumentation and Control Systems. Prior to Fluor she had worked with L&T and Reliance at Jamnagar. She's an avid traveler. She also likes to participate in outreach programs. Culinary and art are her interests outside work.

NurseBot: Automating the Health Care Industry

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ABSTRACT

The robotic distribution of medications in hospital wards utilising artificial intelligence techniques is investigated in this study, which takes into account the safety and medical concerns of patients as well as those who provide drugs on time. The robot uses an intelligence-based system based on sensors and indications placed throughout the wards to traverse the shortest feasible course through the wards before departing. The programme would ensure that the robot did not collide with other robots or humans along the way, and it would also search for signs that the medicine needed to be administered immediately. Rather of utilising a time-consuming manual technique, we can ensure that infectious illnesses are not transmitted when the drug is administered this way. The functionality and algorithm of this suggested technique were tested on a prototype arena and proven to be effective in the laboratory using a NurseBot robot. The proposed approach saves time and resources, and it's easy to execute with outside monitoring from the hospital reception.

KEYWORDS

Robotics, Arduino, Medicinal Robots, Covid-19, Artificial Intelligence, Sensors and Actuators.

INTRODUCTION

Autonomous driving systems will be the cutting-edge technology for delivering in-house hospital medicine in the future. The Robotic Medicine Delivery Systems (RMDS) [1] are similar to self-driving cars that may be found in shopping mall basements, tech parks, residences, and other commercial structures. The most essential characteristics are operational speed, precision, safety, reliability, cost-effectiveness, convenience, and space; efficiency and eco-friendliness are also crucial in these systems. Some patients' access to medicine is impeded, which is a tough procedure. The RMDS's ability to do its work effectively due to a scarcity of competent experts has resulted in a major decrease in research in these areas. The most important aspect in deciding logistics would be the whole time it takes for a truck to enter and distribute medicine. If this interval was kept as short as possible, the whole reasoning involved in the supply of medicine and health issues in diseases like COVID-19 (Coronavirus Disease) would be minimised. Smartphones are becoming more powerful as time goes on, with faster processors, larger storage capabilities, more entertainment options, and more ways to communicate. Bluetooth is

mostly used for data transfer, but it can also be used to add additional functionality to smartphones. A smartphone is a phone that is built on a mobile computing platform and has more advanced computer and connectivity capabilities than a feature phone. Smartphones are more cost-effective and efficient hand-held devices that can be utilised to facilitate community collaboration. ich have a market share of 12.9 per cent and 3.6 per cent, respectively. In response to the rapidly growing number of smartphone owners, millions of Android programmes (Android apps) have been produced to enhance every aspect of life, including home automation systems, everyday arrangements, mobile databases, and entertainment systems. Human presence in digital and vertical environments is essential as a result of increased functional integration in portable devices. Combining embedded technologies with human operations to control external devices is one possibility.

Arduino is open-source electronics prototyping platform for those who wish to build interactive objects or environments. It provides schematics and flexible development kits. Arduino can sense the environment by using different transducers to receive and interpret inputs and provide reactions like motor control or data transmission.

Android has been the most extensively used operating system across the whole range of PCs, phones, and other terminal devices since 2010, surpassing iPhone, Blackberry, and other operating systems. It's an open-source mobile platform created by Google that's designed for touchscreen devices and has direct operations that replicate real-world motions like touching, sliding, and shaking. These direct manipulations are considered to be caused by internal components such as proximity sensors, accelerometers, gravity sensors, and gyroscopes. For example, changing the phone's angle might affect the alarm clock's suspension.

DESIGN SPECIFICATION

Fig1. 3D Design of the Nurse Bot

The figure 1. demonstrates the 3D diagram of the Nurse Bot that has been designed using Autodesk Fusion 360[3]. Essentially, the design has been split into three parts which namely are:

i) Electronic and Power Storage unit: For this purpose, the lowermost compartment is being used which will contain all the electronic components such as the Arduino board. Additionally, it will also contain the main battery that is used to power the entire bot. On top of the chamber, a metal plate has been designed with a few holes, this allows for the wires to pass easily through it and connect the components that are attached towards the upper side of the bot.

ii) Sanitizing Unit: This unit consists of two elements, the UV disinfectant tube, and the sanitizer sprayer. There are 6 UV tubes that are attached to the central area of the bot. Which is why the central area has been kept hollow for the UV rays to spread appropriately and ensure high sanitizing efficiency. Furthermore, a small storage compartment has been placed on top of the metal plate, where the sanitizing liquid will be stored, and will be pumped up to the sprayer that is placed on the side of the tray.

iii) Delivery Unit: This unit simply consists of a tray that has been attached to the top of the bot that can be used to deliver a variety of things to the patient such as food and medicines. To avoid the falling of items placed in the tray, the walls of the tray have been extended adequately. Moreover, the IP camera has been placed on the periphery of the tray.

Lastly, in terms of the movement of the Nurse Bot, the bot has been equipped with three wheels, two of which are connected parallelly and rotate with the help of a DC motor, while the third wheel is a free/universal wheel. All the wheels have been placed at appropriate locations after analysing various angular measurements in order to ensure the proper balancing and no hindrance in the motion of the bot

COMPONENT SPECIFICATION

This is a list of the basic components going to be used in the project:

Sr. No.	Component	Specifications
1.	Arduino Uno	ATmega328P
2.	Ultrasonic Sensor	HC-SR04
3.	Motor Driver	L298N
4.	Bluetooth	HC-05
5.	UV Disinfecting Tube	
6.	Mist Spray	
7.	DC Motor	

Table 1. Component Specification of the NurseBot

- **Arduino Uno: -**

Arduino is an open-source platform that enables users to work on a lot of different electronics projects that range from simple traffic light control using LEDs to complex projects like movement of a robotic arm. This is achieved by simply connecting a B- type USB cable from the Arduino to our computers and giving it the required code for its function. For programming there is a separate IDE specially designed in C++ language. In the IDE the user must first correctly find out all the pins he has connected the I/O's to and the specify whether it's an input or an output using the setup () function. Later he must specify

whether its active or not in the Loop () function and this part keeps on running whereas the setup () function is only initiated once[4]. Once this program is compiled and runed without errors we will be able to see the results we wanted. Now coming to the Arduino Uno board, an Arduino Uno which is the most common and widely used in many projects consists of:

1.A power jack- This helps to keep the Arduino up and running even when it is not connected to the computer.

2.A power rail- This allows the user to the give the initial power supply to the Arduino. It even has a reset pin and ground connections. 3.3V and 5V pins are given on the Arduino. Arduino Uno works between 2.7V to 6V.

3. Analog Pins: - These pins take analog inputs (Accelerometers, light sensors, temp. sensors). The pins are from A0-A5. Since Arduino boards have a 10-Bit analog to digital converter the values for analog can range anywhere between 0 to 1023.

4. Digital Pin: - There are 14 digital pins on an Arduino Uno board (D0-D13). They can only be switched in two states unlike analog, High or Low (+5V or 0V). There are many digital pins which have different functions such as:

- Serial In (Rx) and Serial Out (Tx): - These pins allow the user to communicate with other Arduino boards and can also be used as master/slave.
- Interrupt Pins: - Pin2 and Pin3 on an Arduino are specified for interrupt pins. These pins are given highest priority.
- PWM (Pulse Width Modulation): - There are 6 PWM pin on an Arduino board (D3, D5, D6, D9, D11). PWM has a frequency of around 500Hz and works on the principle of duty cycle. This means 100% duty cycle is for ON state and 0% for OFF. Analog inputs (analog write ()) are given on these pins.
- **Microcontroller (ATmega32P): -** Lastly the microcontroller which is the brain of the Arduino is used for all the computations. In an Arduino Uno usually Atmel 8-bit ARV microcontroller is used. This also has many features such as:

Microcontroller	ATmega32P
Operating Voltage	5V
Digital I/O Pins	14
Analog input Pins	6
Flash Memory	32 KB
SRAM	2KB
EEPROM	1 KB
Clock Speed	16MHz

Table 2. Specification of ATmega32P

All these parts on the board can be increased by adding shields such as motor shields, communication shield, Bluetooth Shield, etc so that a user can perform more complex tasks on the same Arduino.

- **Motor Driver(L298N): -** Motor Driver (L298N) [5]is used in helping motors to be accessible with an Arduino. Motors generally requires high initial torque which can only be achieved with the help of external motor drivers which is a Dual H-bridge motor driver. Since an Arduino works on low current a motor current helps to increase that voltage so that it can control the direction and speed of the motor. This motor driver can take voltages from 5V up to 35V.

- **Bluetooth (HC-05): -** This module is used for wireless communication. Since this module is compactable with SPP (Serial port protocol) it can act as master/slave type and can be paired with another Arduino also. Bluetooth (HC-05)[6] can be paired by starting the serial monitor (Serial. begin (9600)) and then in the monitor type AT+ the name. This module works in the range of below 100m and can work on a voltage in the range of 4V to 6V.

- **UV disinfecting Tube: -** UV light[7] helps in killing germs and bacteria by using UV light which is invisible to the human eye. These Ultraviolet rays along with some water and chemicals reach the cell and damage the DNA which prevents them from multiplying. UV light not only helps in getting rid of the bacteria and germs on surfaces and air but also make water cleaner to drink.

- **Mist Spray: -** The advantage of mist spray over any other sanitizer is that it doesn't dirty the surrounding by making it wet or your hands sticky. It is just vapour which contains some ions that change into anions in air and get attracted to our skin by moisture. Since it is compact and only has to be charged once, it can be kept in our pockets and taken wherever we go.

- **DC Motor**: - Motors are electrical devices that are used in objects for rotational motion. DC motors convert electric energy to mechanical energy. Motors are used in many applications in our daily life such as cooling fans, toy cars, etc. Most DC motors have 2 components a rotor (Rotating part) and stator (stationary part). These parts are suspended around a shaft that runs along the centre of the motor on which power is transferred. DC motors have a permanent magnet on either side the rotor and coils. The main working principle of Motors is that when current is passed through a coil in a magnetic field the coil rotates due to the resulting torque generated and the motor starts to run.

RELATED WORKS

The major growth in automation across various fields such as the medical[8], has no longer kept the idea of creating a medicine delivery bot or a sanitizing bot unique. There have been many such robots created and demonstrated in various papers. This section of the paper will bring forward the past work that has been done in making such bots. Keywords such as “Medicine Delivery Bots” and “Sanitizing Bots”[9] were used to search for the relevant sources that are incorporated within this section. Additionally, websites such as Google Scholar and IEEEXplore were also referred to find relevant works to the study.

Such a bot has been described in the work [10], where the author demonstrates on designing a low-cost path following robot that is used for delivering various items in place of the nursing staff available in the hospitals.

Moreover, as mentioned by the author in[11], there have been sanitization bots developed such as the **Xenex Germ-Zapping Robot**, that makes use of UV rays for sanitization, replacing the manpower that goes in sanitizing, large hospital rooms.

The proposed Nurse Bot will not only contain all the features that have been included in the above-mentioned bots but will incorporate both the delivering and the sanitizing unit within a single robot unlike the ones mentioned above.

METHODOLOGY

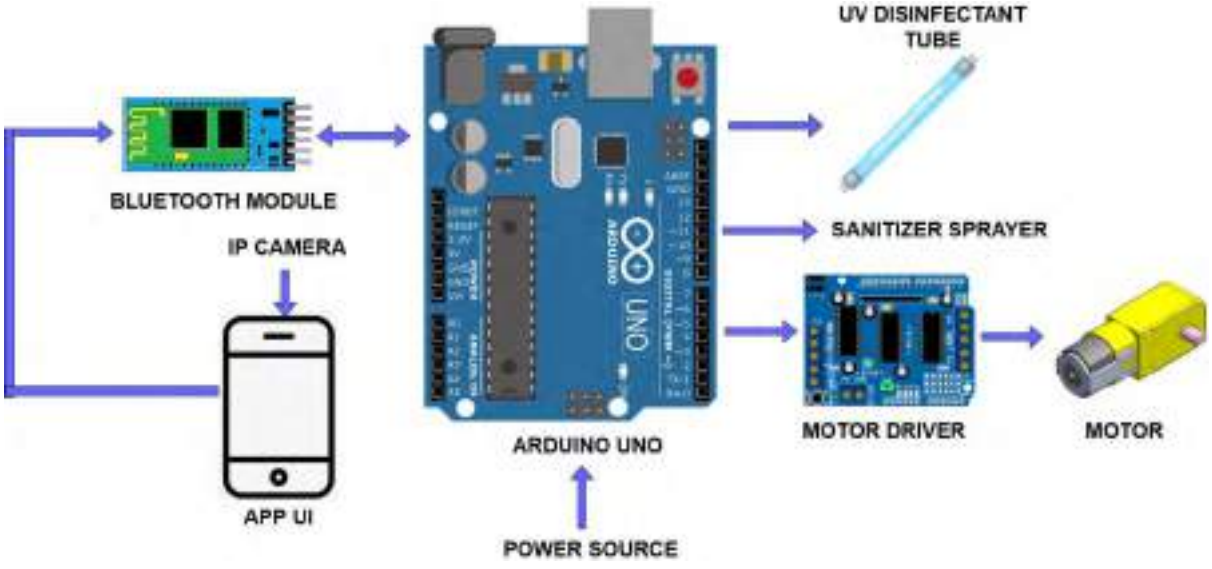

Fig2. Component Flowchart of the NurseBot

The figure 2. shows the flowchart of the Nurse Bot which summarizes the flow of data between various components of the bot. All the user inputs such as controlling the motion of the bot, switching ON/OFF

the UV disinfectant tube are given through the app to the Bluetooth module, which in turn sends this data to the Arduino Uno. According to the data the board receives from the Bluetooth module, it has been programmed to perform specific functions such as rotating the motor, switching ON the sanitizer sprayer.

ALGORITHM TO CONTROL THE BOT

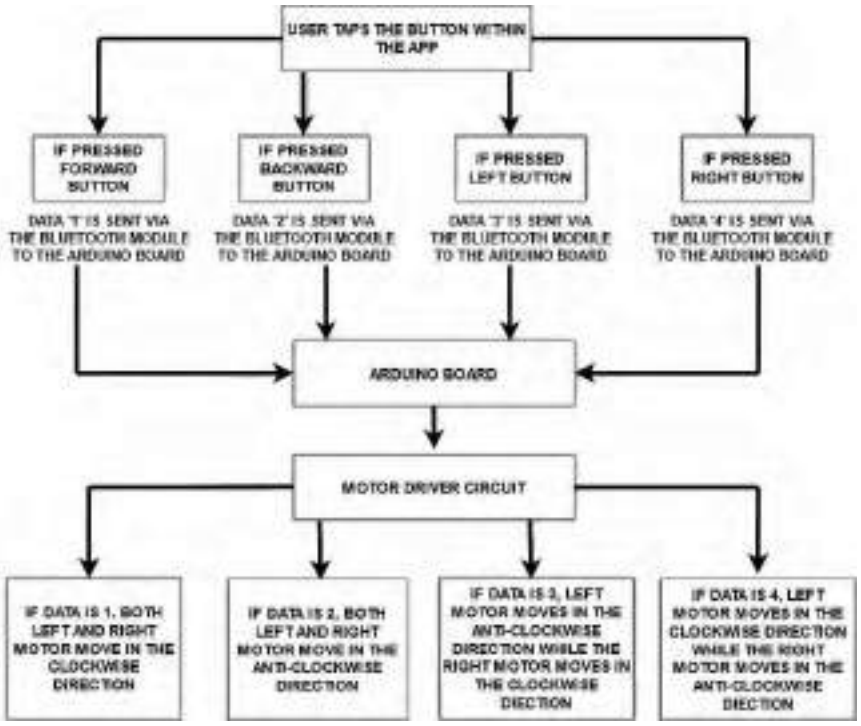

Fig3. Algorithm used to control the NurseBot

The figure 3. shows the algorithm that has been used to control the motion of the bot. The app designed using the MIT App Inventor is used to take the user input for controlling the bot. Based on these inputs the Arduino board receives data from the Bluetooth module and instructs the motor driver circuit to rotate the motors in the required direction.

As the user presses the forward button on the app, the data is passed to the Bluetooth module, which sends the value ‘1’ in this case to the Arduino board. The Arduino board has been programmed using the Arduino IDE, where the code contains various if, else statements. In the case where the Arduino receives the value 1, it is programmed to send the signal to the motor driver to rotate both the left and the right motor in clockwise direction. Similarly, in case the user presses the backward button on the app, the Bluetooth module sends the value ‘2’ to the Arduino which in turn sends the signal to the motor driver to rotate both the left and the right motor in the anti-clockwise direction.

When it comes to turning, the bot is designed to do a point turn. If the user hits the left button, the Bluetooth module transmits the value ‘3' to the Arduino board, which instructs the motor driver to rotate the left motor anti-clockwise and the right motor clockwise. Similarly, a value of 4 is given to the

Arduino board upon turning right, instructing the motor driver to rotate the left motor clockwise and the right motor clockwise.

WORKING FLOWCHART

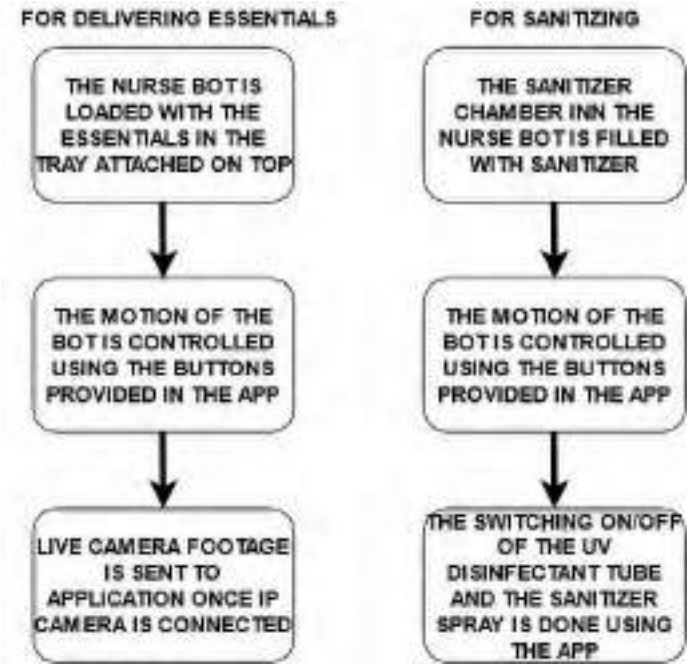

Fig4. Working Flowchart of the NurseBot

Figure 4. shows the flowchart of how the working of the Nurse Bot works. The working has been divided into two phases, the delivering of essentials and the sanitizing the surroundings.

Delivering of essentials: Initially, the Nurse Bot is loaded with the essentials such as food/medicines that need to be delivered to the patient; the motion of the bot is then controlled using the app created, which also sends the live footage to the user's smartphone using the IP Camera attached to the bot.

Sanitizing: The bot has been equipped with two ways of sanitizing the environment, using liquid sanitizer, or using the UV rays. To sanitize using the UV rays, the user simply needs to switch ON the UV tube using the button provided in the app. Whereas, to sanitize using the liquid sanitizer, the sanitizer chamber must be filled with the sanitizer, then using the button provided within the app, the sanitizer sprayer must be switched ON.

APPLICATION UI

Fig5. Application UI of the NurseBot

Figure 5. shows the user interface of the application that is being used to control the various functionalities of the Nurse Bot. The application is designed using MIT App Inventor. The application consists of an area where the live footage from the IP camera will be shown as soon as the IP address of the camera is entered into the "Camera IP Address" field and the "Connect to Camera" button is pressed.

The motion of the robot can be controlled by, clicking on the "Connect to Bluetooth" button, which connects the application to the Bluetooth module situated in the bot. Once the connection has been established, the bot can be moved in the required direction by using the 4 direction buttons that are provided within the app. Lastly, there are four buttons provided for switching ON/OFF the UV disinfectant tube and switching ON/OFF the sprayers that are used for sanitizing the surroundings. The Bluetooth connection can be disabled by clicking on the "Disconnect" button.

RESULTS

Unlike humans, bots are not required to wear masks and other protective equipment's within the hospital environment. Additionally, they can work at the same pace for hours without showing any lack of efficiency, thus bots such as the Nurse Bot can easily be deployed withing each and every hospital for

delivering essentials and sanitizing the rooms in place of the hospital staff. This would ultimately result in reducing the number of Covid 19 cases among the medical staff.

CONCLUSION

Wireless control is one of the most crucial basic requirements for everyone on the planet. However, because of a large volume of data and connection overheads, the technology is not completely utilised. RF modules are commonly used in wirelessly controlled robotics. However, our robotic control concept makes use of an Android phone, which is inexpensive and widely available. To accomplish this, the Android user must download and install a specially built application on their device. The user can interact with the UI of the app which sends commands from the Android mobile to travel backwards, forwards, left, and right, among other things. The proposed method also demonstrates how a medical robot can be employed. A wireless camera has been utilised for this purpose, allowing us to see, take images, and record videos on the application itself. It has been demonstrated to enable real two-way communication between the Android phone and the robot, allowing a non-expert to interact with and alter the functionality of an Arduino Uno system. It is hoped that the current action will lead to future improvements in this vein. GSM, for example, can be used instead of Bluetooth to extend the communication range.

FUTURE SCOPE

In an era of austerity, ageing and increasing populations, and medical manpower shortages, the health business is undergoing a quiet robotic revolution. The economics of advanced medical equipment, with its formerly expensive cost, did not allow for its quick adoption in our cash-strapped public hospitals or even better-off private institutions. We could expect to see more robotic gadgets in our hospitals as operational costs fall and healthcare authorities seek for innovative methods to save money. In fact, if you need surgery in the future, you may expect your surgeon to use robotic help. Because of pinpoint precision, exceptional Artificial Intelligence (A.I.) and sophisticated algorithms, the presence of a robot will make your operation safer, faster, and more sanitary. Medical robotics is already cutting healthcare costs by eliminating human errors, simplifying operating rooms, reducing operating time, and, most significantly, freeing up workers to focus on more pressing issues by assisting hospitals with surgical and other tasks. However, the implementation of such technology must be hastened. If present trends continue, the worldwide needs-based deficit of healthcare personnel would be more than 14 million by 2030, according to World Health Organization projections. Experts, such as Dr Bertalan Mesko, PhD, founder of the Medical Futurist website, believe that technology will be the key to solving these challenges. According to Mesko, automation techniques such as artificial intelligence robots and 3D printing will help to make healthcare more sustainable and efficient in the future. According to a recent study conducted in England, NHS hospitals could perform 17 percent (280,000) more non-emergency operations each year if operating theatre schedules were properly planned. The study showed that

individuals waste more than two hours each day on average, based on data from operating theatres in 100 NHS Trusts throughout England in 2016.

As a result, operating rooms are likely underutilised, with each surgery growing more expensive as a result. Artificial intelligence and robotics are two technologies that have showed promise in addressing and resolving a variety of current concerns. For a long time, robots have been used in the manufacturing industry. However, robots have been used in a variety of fields throughout the last three decades, including laboratory research, earth and space exploration, transportation, and many more. Robotics have reduced production costs and enhanced productivity, while also resulting in the development of much new employment in the tech industry, as well as economic growth. Robots are typically used for activities that need repetitive and tedious work; nevertheless, the reach of Artificial Intelligence (AI) is expanding. They are taking the place of human workers and delivering effective outcomes. Production automation is accelerating over the world, according to the International Federation of Robotics: The current global average for robot density in industrial industries is 74 robot units per 10,000 employees (2015: 66 units). As robots' capabilities and applications improve, industries such as healthcare and its related professions are embracing them to do various jobs. Robots are being utilised in complex surgeries, clinical teaching, medicine dispensing, personal care, and a variety of other applications. Medical robot sales climbed by 73 per cent from 2016 to 2,931 units in 2017, accounting for 2.7 per cent of overall unit sales of professional service robots, according to the International Federation of Robotics. The most important application of robots in healthcare is robot-assisted surgery or therapy. Other services, on the other hand, are seeing a huge increase in demand.

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FINALPROJECT REVIEW

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RollNumber:04511502819, 06311502819, 25 JULY 2021

TOPIC:- AUTO ATTENDANCE SYSTEM WITH FACE RECOGNISATION USING MATLAB

ABSTRACT

Face is the representation of one's identity. Hence, we have proposed an automated student attendance system based on face recognition with the help of matlab. Face recognition system is very useful in life applications especially in security control systems. The airport protection system uses face recognition to identify suspects and FBI (Federal Bureau of Investigation) uses face recognition for criminal investigations. In our proposed approach, firstly, video framing is performed by activating the camera by calling some function in matlab. The face ROI is detected and segmented from the video frame by using Viola-Jones algorithm but in our case the toolbox that is computer vision toolbox provides large no. functions which helps in most of the detection part . In the pre-processing stage, scaling of the size of images is performed if necessary, in order to prevent loss of information. The median filtering is applied to remove noise followed by conversion of color images to grayscale images. After that, contrast-limited adaptive histogram equalization (CLAHE) is implemented on images to enhance the contrast of images. In face recognition stage, enhanced local binary pattern (LBP) and principal component analysis (PCA) is applied correspondingly in order to extract the features from facial images. In our proposed approach, the enhanced local binary pattern outperforms the original LBP by reducing the illumination effect and increasing the recognition rate. Next, the features extracted from the data is then

compared to the face of the user. The facial images are then classified and recognized based on the best result obtained from the combination of algorithm, enhanced LBP and PCA. Finally, the attendance of the recognized student will be marked and saved in the excel file. The student who is not registered will also be able to register on the spot by giving the data of his/her face to the system. The average accuracy of recognition is 100 % for good quality images, 94.12 % of low-quality images and 95.76 % for Yale face database when two images per person are trained. All of the calculations are done with the help of MATLAB and its different toolboxes.

INTRODUCTION

The main objective of this project is to develop face recognition based automated student attendance system. The test images and training images have to be captured by using the same device to ensure no quality difference. In addition, the students have to register in the database to be recognized. The enrolment can be done on the spot through the user-friendly interface.

The making of automatic attendance system involves some crucial steps and these steps are.

- Face detection
- Data collection
- Face recognition
- Automatic attendance system

Fig:-General framework of attendance system

SOFTWARE USED:-

We have used **MATLAB** in order to built the auto attendance system as it provides one of the best environment to code and user friendly toolbox for image acquisition And for detection of face we will study about these toolbox further in our report.

WORKING AND SIMULATION

As described in the intro section the working involves 4 major steps so lets dig in.

1) FACE DETECTION

Difference between face detection and face recognition are often misunderstood. Face detection is to determine only the face segment or face region from image, whereas face recognition is to identify the owner of the facial image.

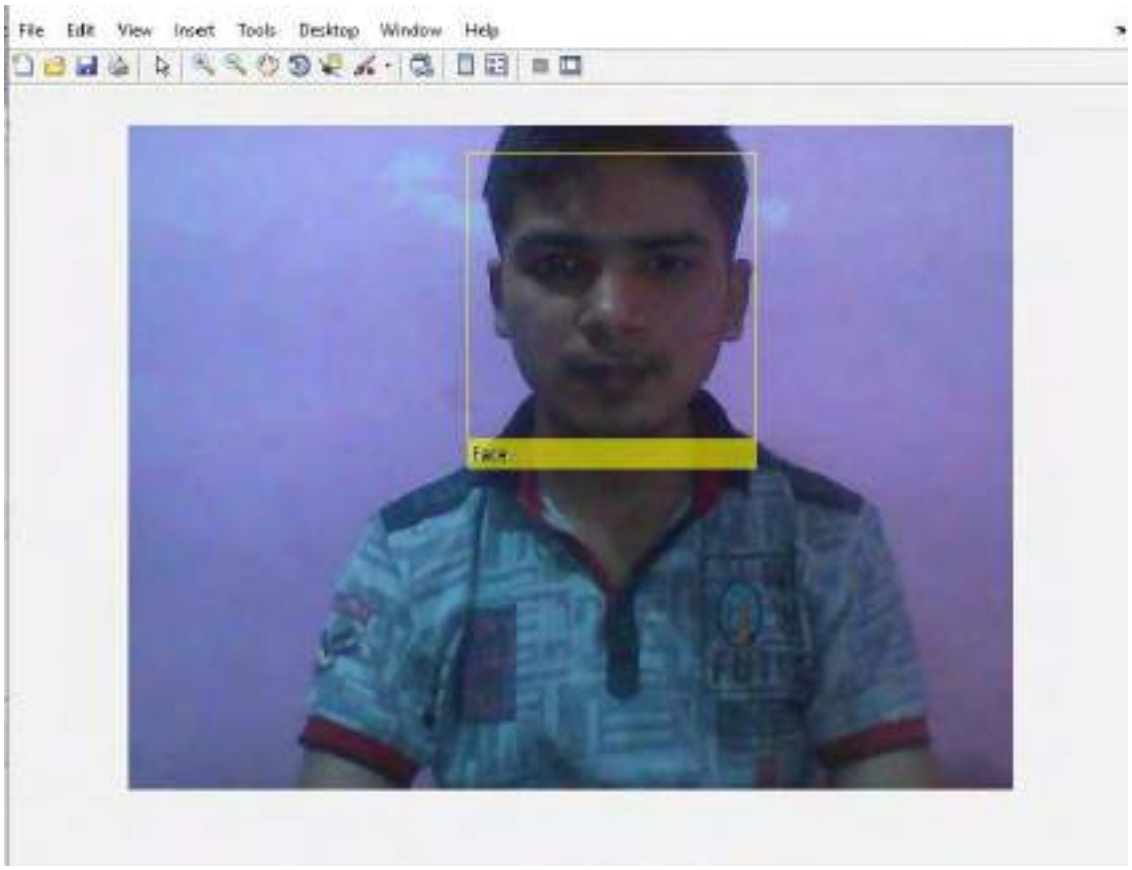
In our case we have used the inbuilt toolbox of matlab that is computer vision tool box along with image processing and acquisition toolbox to capture the image in every second and in this process the images are converted from rgb to grey scale image for extraction of feature and then detection of face in the image. We can also use this toolbox in detection of other types of different object. The command to use the toolbox and its feature that is face detection is **vision.cascadeobjectdetector.**

1.1 Code

face_detection.m | data_collection.m | training_model.m | testing.m

```
clc;close all;
 clear('li');
li=webcam();
im=snapshot(li);
dete=vision.CascadeObjectDetector();
pp=imshow(im);
while true
    im=snapshot(li);
    im2=rgb2gray(im);
    bb=step(dete,im2);
    im2=insertObjectAnnotation(im,'rectangle',bb,'Face');
    imshow(im2);
end
```

1.2 Output



2) Data collection

Data collection plays an essential role to improve the accuracy of face recognition. Scaling is of image is part of data collection and the important preprocessing steps to manipulate the size of the image. Scaling down of an image increases the processing speed by reducing the system computations since the number of pixels are reduced. The size and pixels of the image carry spatial information. The size should be same for all the images for normalization and standardization purposes. To extract features from facial images, same length and width of image is preferred, thus images were scaled to 120 × 120 pixels.

Besides scaling of images, colour image is usually converted to grayscale image for pre-processing. Grayscale images are believed to be less sensitive to illumination condition and take less computational time. Grayscale image is 8 bit image which the pixel range from 0 to 255 whereas colour image is 24 bit image which pixel can have 16 77 7216 values. Hence, colour image requires more storage space and more computational power compared to grayscale images. If colour image is not necessary in computation, then it is considered as noise.

2.1) Code

Untitled3.m | Untitled4.m | myfacedetect.m | facedata.m | datacollection.m

```
clc
clear all
close all
warning off;
cao=webcam;
faceDetector=vision.CascadeObjectDetector;
c=30;
temp=0;
while true
    e=cao.snapshot;
    bboxes =step(faceDetector,e);
    if(sum(sum(bboxes))~=0)
    if(temp>=c)
        break;
    else
    es=imcrop(e,bboxes(1,:));
    es=imresize(es,[227 227]);
    filename=strcat(num2str(temp),'.bmp');
    imwrite(es,filename);
    temp=temp+1;
    imshow(es);
    drawnow;
    end
    else
        imshow(e);
        drawnow;
    end
end
```

2.2) Output

3) Face Recognition

Face Recognition Technique (FRT) can only recognize a face if a specific individual face has alreadybeen added to the system in advance. Hence this step involves testing and training process through which we can distinguish between different faces.Thecondition of the enrolment and the quality of resulting image have significant impact on the finalefficiency of FRT. In the process of testing we have used one of the toolbox from MATLAB that is **Deep learning toolbox model for akexnet.** Basically this toolbox stores all the features of the trained database in the form of numerical digits these digits are extracted data of images in the form of pixels.

Now how face recognition works, Facial recognition software is based on the ability to first recognize faces, which is a technological feat in itself. If you look at the mirror, you can see that your face has certain distinguishable landmarks. These are the peaks and valleys that make up the different facial features.

These landmarks are defined as nodal points. There are about 80 nodal points on a human face. Some of them are:-

- Distance between the eyes
- Width of the nose
- Depth of the eye socket
- Cheekbones
- Jaw line
- Chin

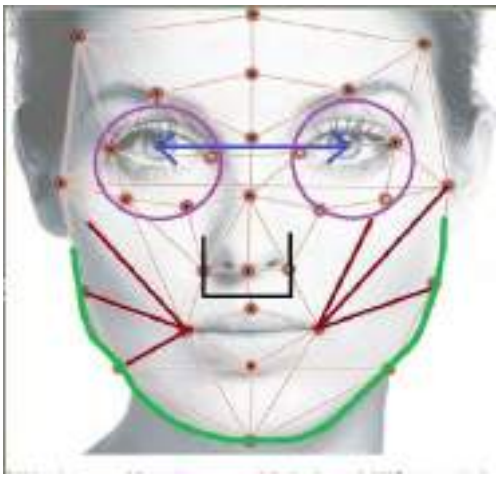
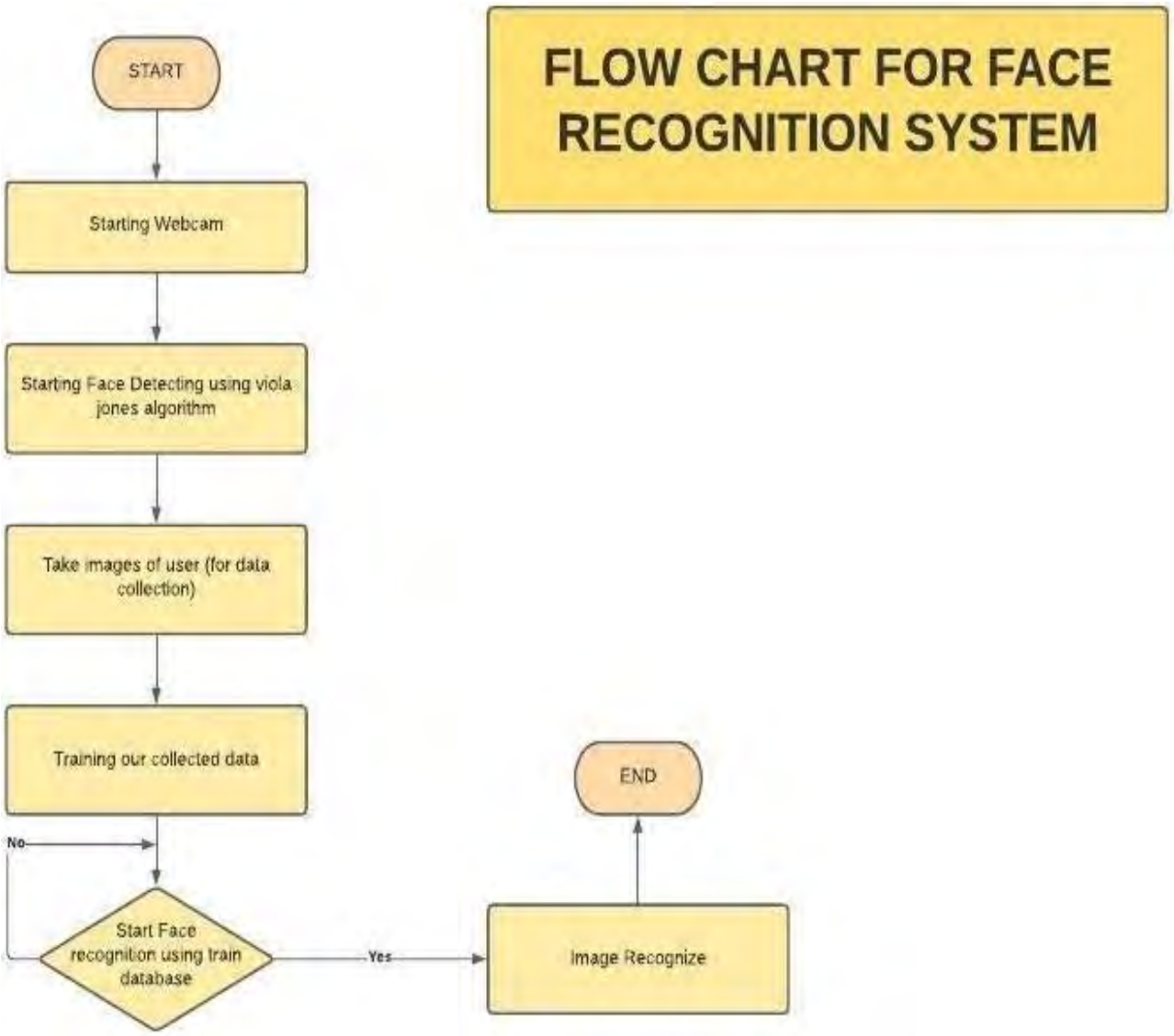


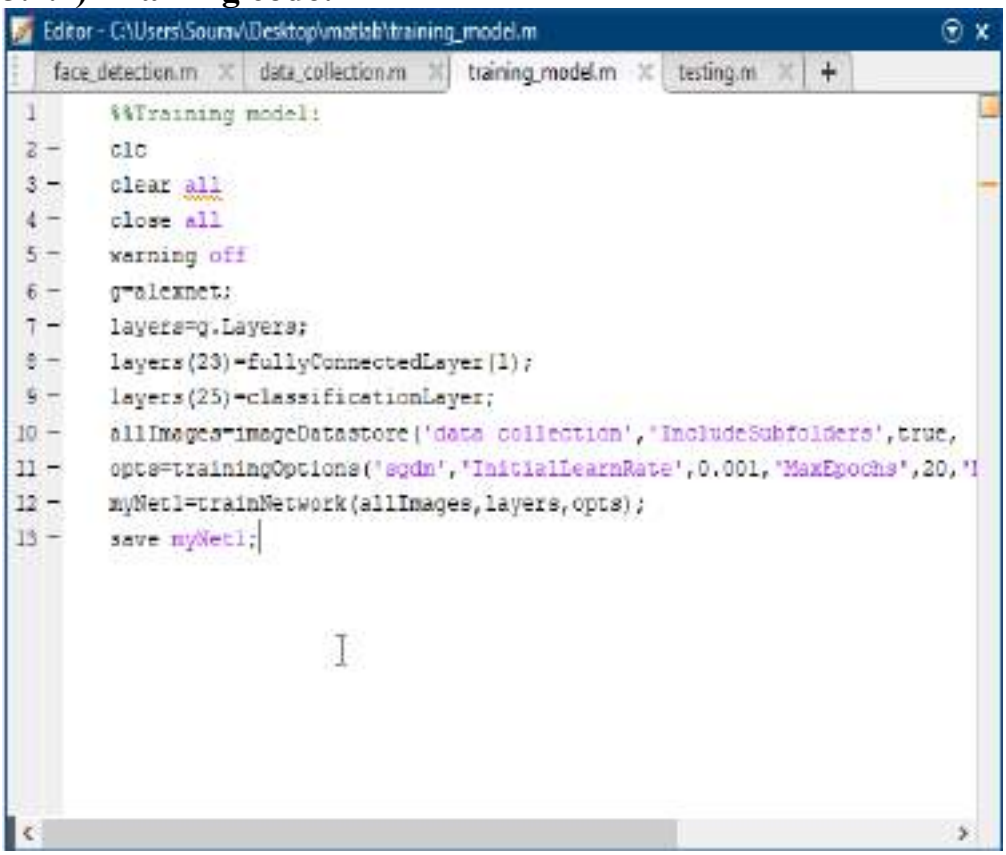
Fig :- Nodal points on a human face

3.1 Block diag. of Face recognition



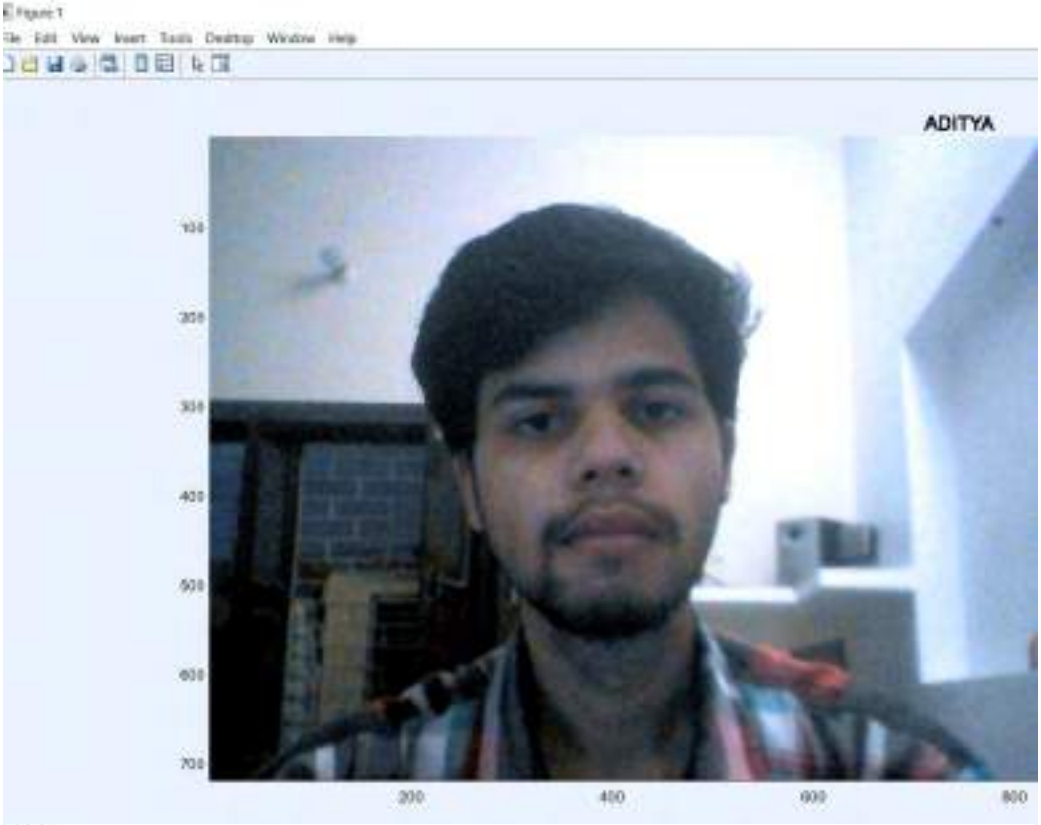
3.2) Code

3.2.1) Training code:-



3.2.2)Testing code:-

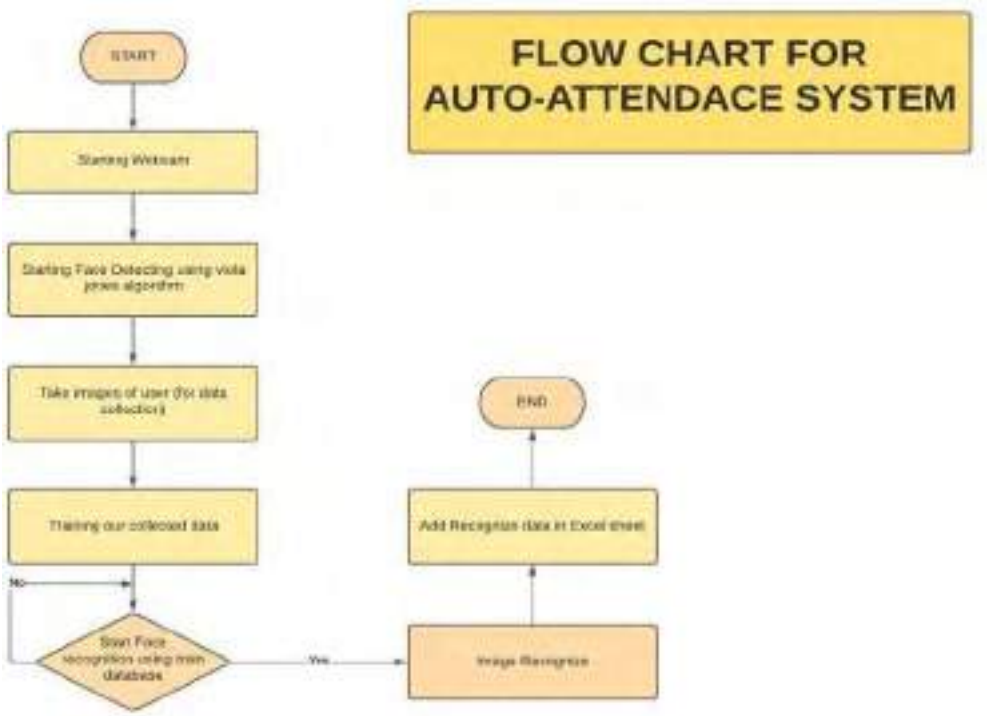
3.3) OUTPUT



4) AUTOMATIC ATTENDANCE SYSTEM:-

The last step involves the marking of attendance after the system recognises the face. The attendance will going to be marked on an excel sheet by using the inbuilt function of MATLAB that is xlswrite('foldername',data, , 'range of sheet').

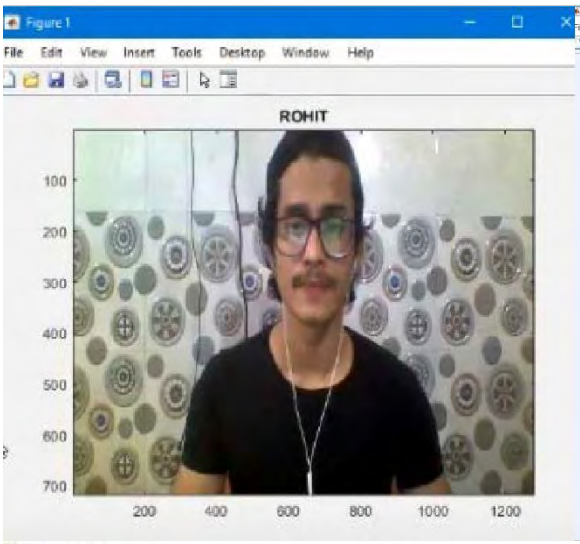
4.1) Block diagram of automatic attendance system

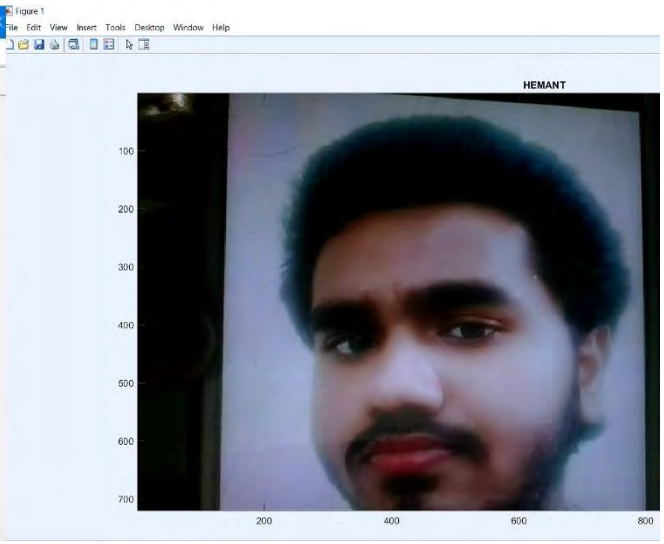


4.2) Code:-

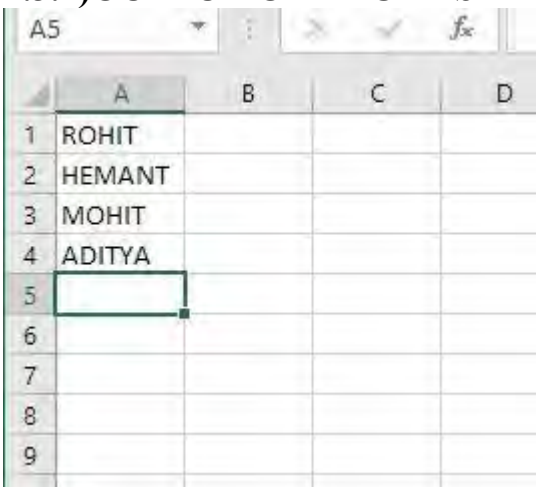
```
%%auto attendance code:
clc;close all;
clear all;
clear('c');
c=webcam;
load myNet1;
faceDetector=vision.CascadeObjectDetector;
i=0;
while i<20
    a=c.snapshot;
    bboxes =step(faceDetector,a);
    if(sum(sum(bboxes))~=0)
     es=imcrop(a,bboxes(1,:));
    es=imresize(es,[227 227]);
    label=classify(myNet1,es);
    image(a);
    title(char(label),'color','black');
    drawnow;
    i=i+1;
    else
        image(a);
        title('No Face Detected');
    end
end

s = xlswrite('Book1.xlsx',cellstr(label),'','A1')
```

4.3) OUTPUT:-





4.3.2)OUTPUT OF EXCEL SHEET:-



	A	B	C	D
1	ROHIT			
2	HEMANT			
3	MOHIT			
4	ADITYA			
5				
6				
7				
8				
9				

RESULT

In this proposed approach, face recognition student attendance system with userfriendly interface is designed by using MATLAB. With the help of each sophisticated code each provides specific function, for example, detection code simply shows the process of detection and data collection simply collects the data of new user. Lastly the main attendance code in which by simply running it we can first recognise the face and then if face is recognised it automatically mark attendance in the excel sheet.

CONCLUSION

In this approach, a face recognition based automated student attendance system is thoroughly described. The proposed approach provides a method to identify the individuals by comparing their input image obtained from recording video frame with respect to train image. This proposed approach able to detect and localize face from an input facial image, which is obtained from the recording video frame. The algorithm designed to combine LBP and PCA able to stabilize the system by giving consistent results although all the calculations are done internally with the help of toolboxes. The accuracy of this proposed approach is 100 % for high-quality images, 92.31 % for low-quality images and 95.76 % of Yale face database when two images per person are trained.

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- https://in.mathworks.com/matlabcentral/answers/index

Session – 4

Bringing Intelligence to Industrial AI

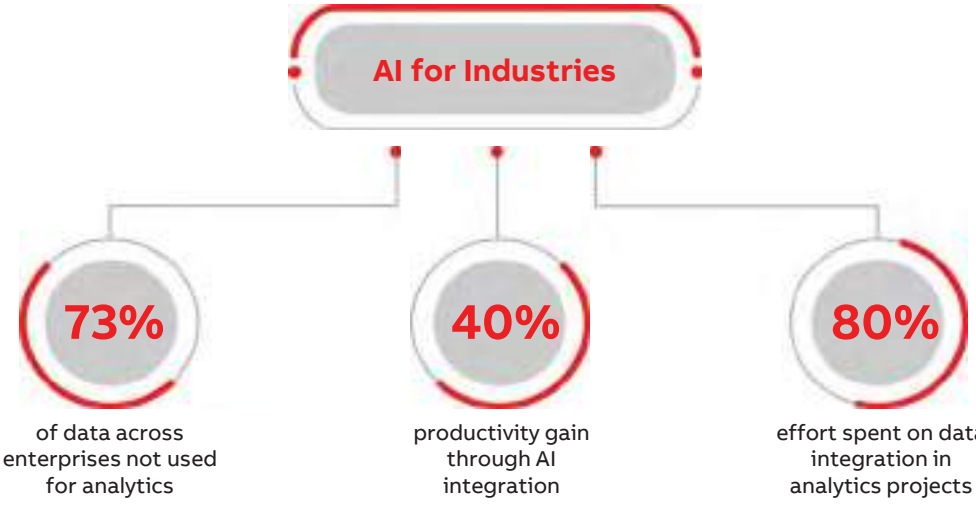
Opportunities, Challenges, Requirement for success

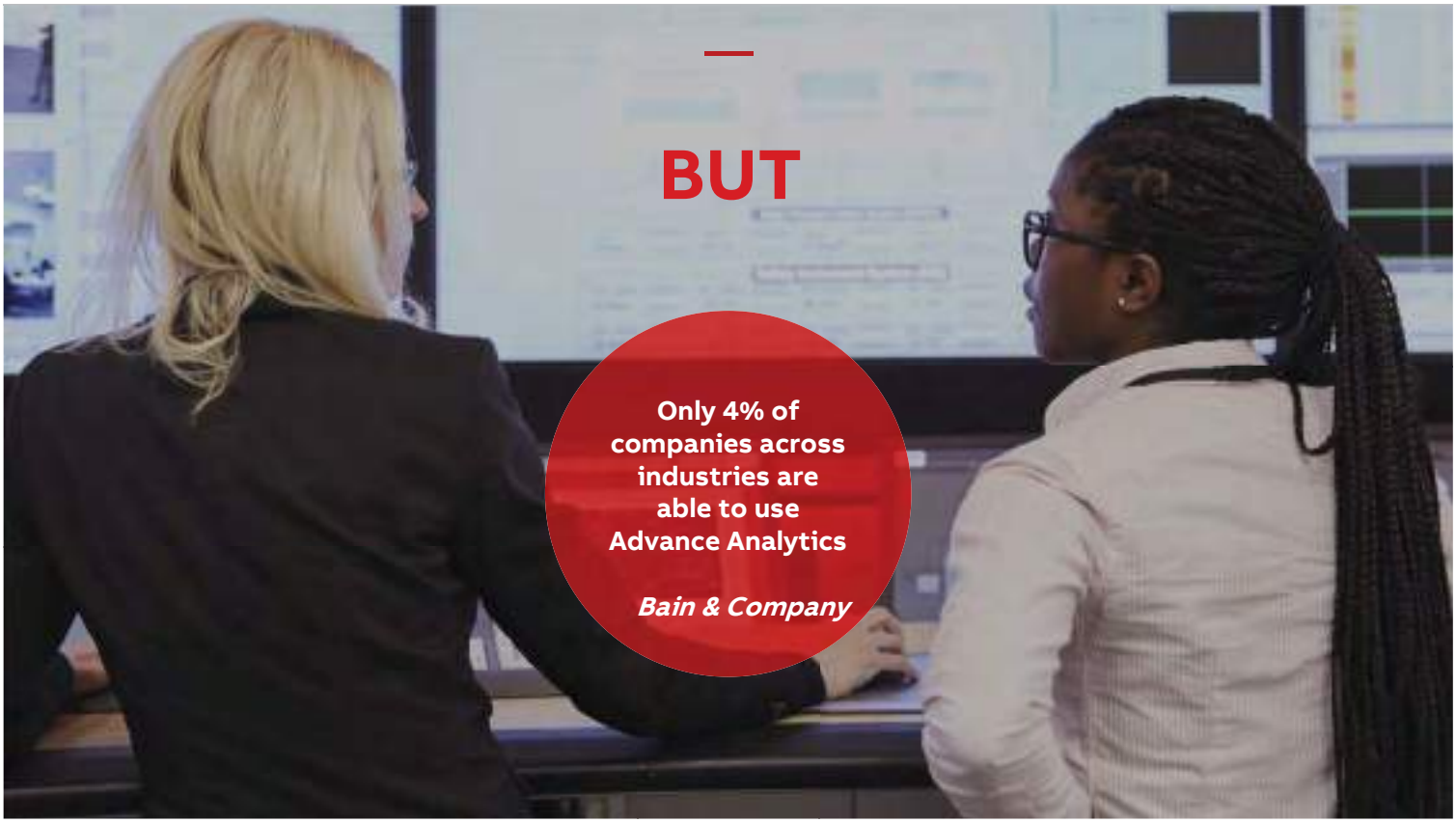
Aninda Bhattacharya, ABB PA Digital

 Document ID.: Rev.:

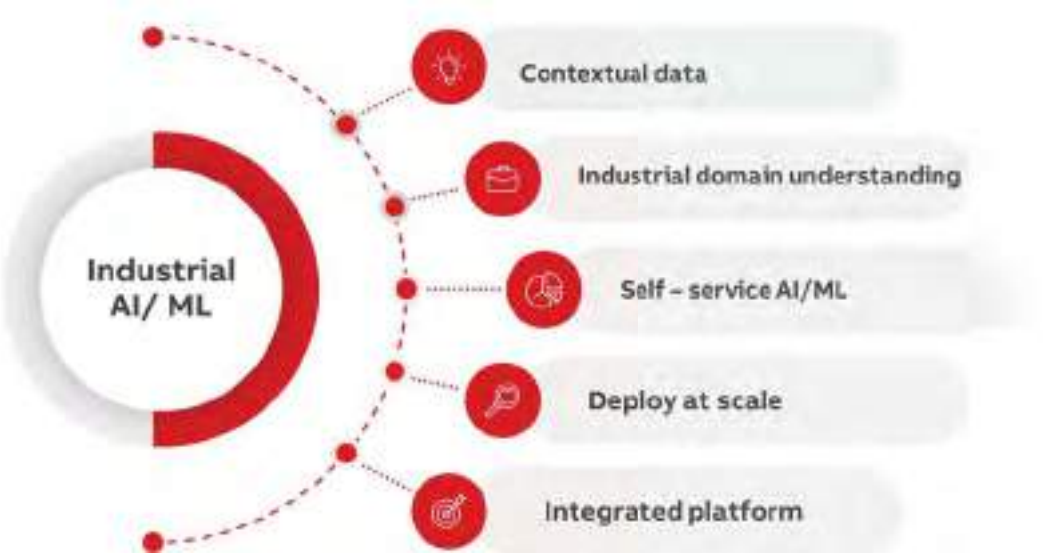
Unlocking the potential of AI

Harnessing the power of structured data approaches and analytics



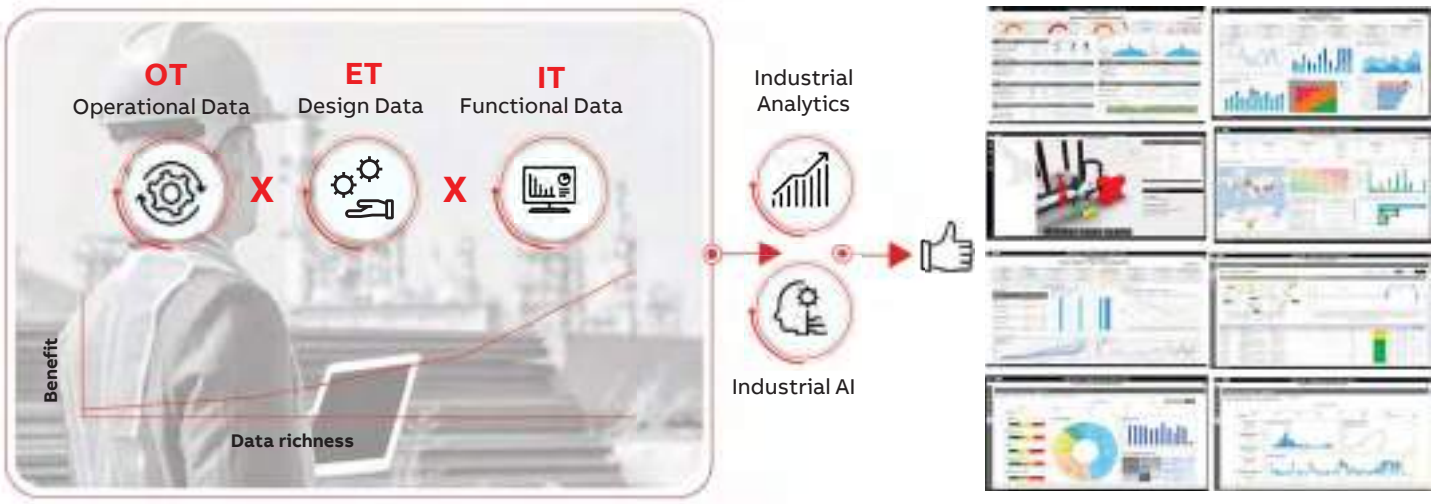


Use of AI/ML in Industries – Key Success Criteria



1.Contextual Data - The eXponential factor

Multifold value of DATA driving business outcomes



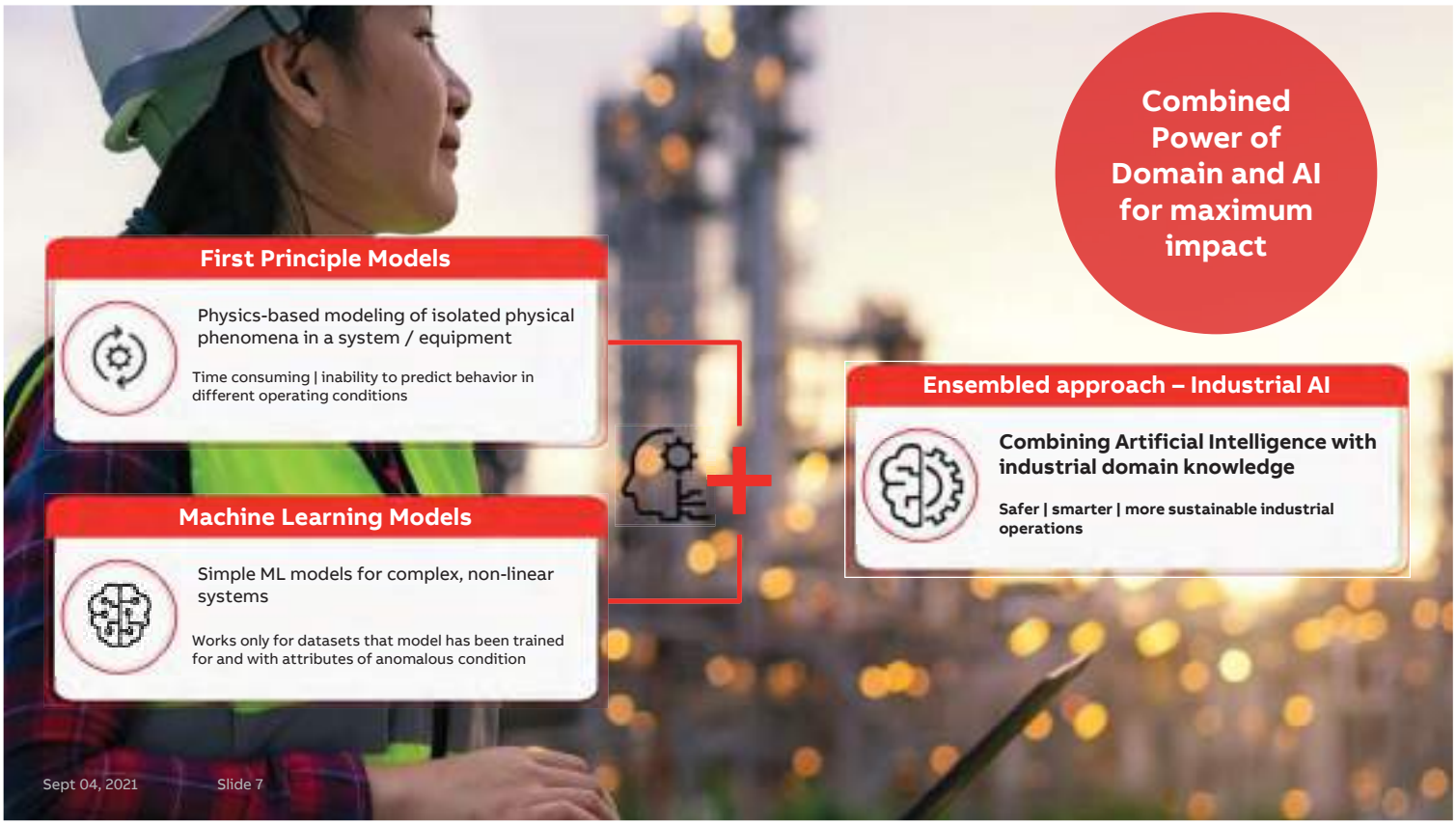
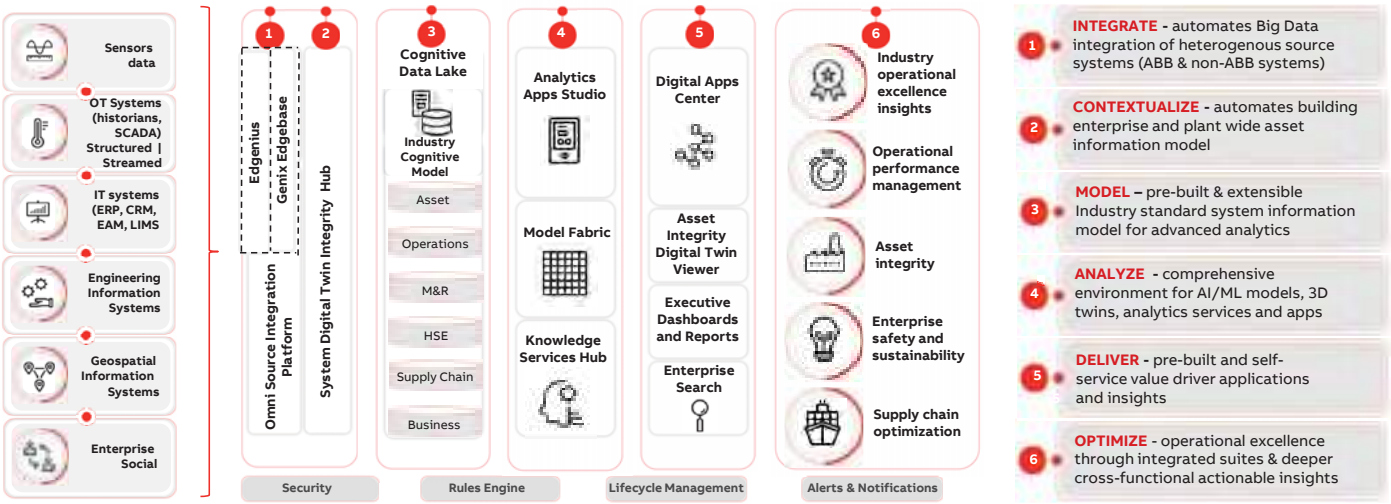


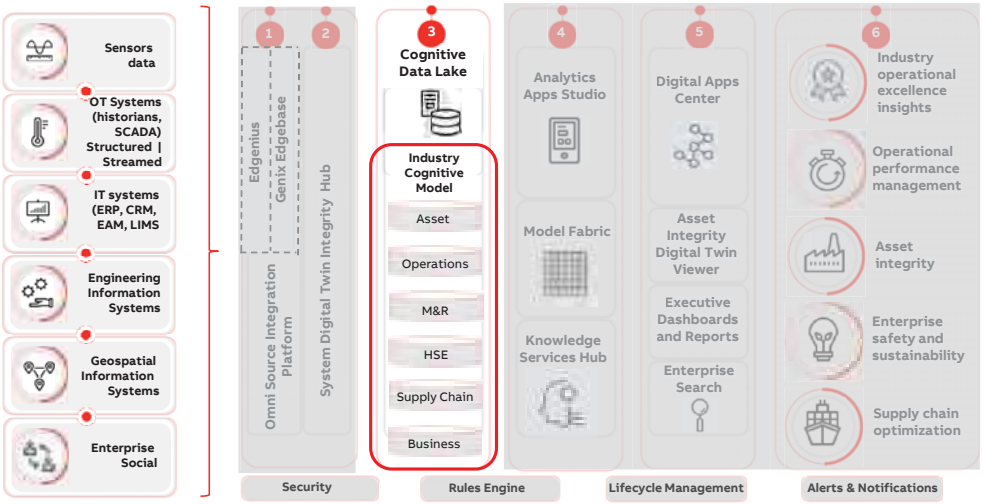
ABB Ability™ Genix Industrial Analytics and AI Suite

Enterprise grade modular, open standards based, deployment across edge, on-premise and multi-cloud



1. **INTEGRATE** - automates Big Data integration of heterogenous source systems (ABB & non-ABB systems)
2. **CONTEXTUALIZE** - automates building enterprise and plant wide asset information model
3. **MODEL** – pre-built & extensible Industry standard system information model for advanced analytics
4. **ANALYZE** - comprehensive environment for AI/ML models, 3D twins, analytics services and apps
5. **DELIVER** - pre-built and self-service value driver applications and insights
6. **OPTIMIZE** - operational excellence through integrated suites & deeper cross-functional actionable insights

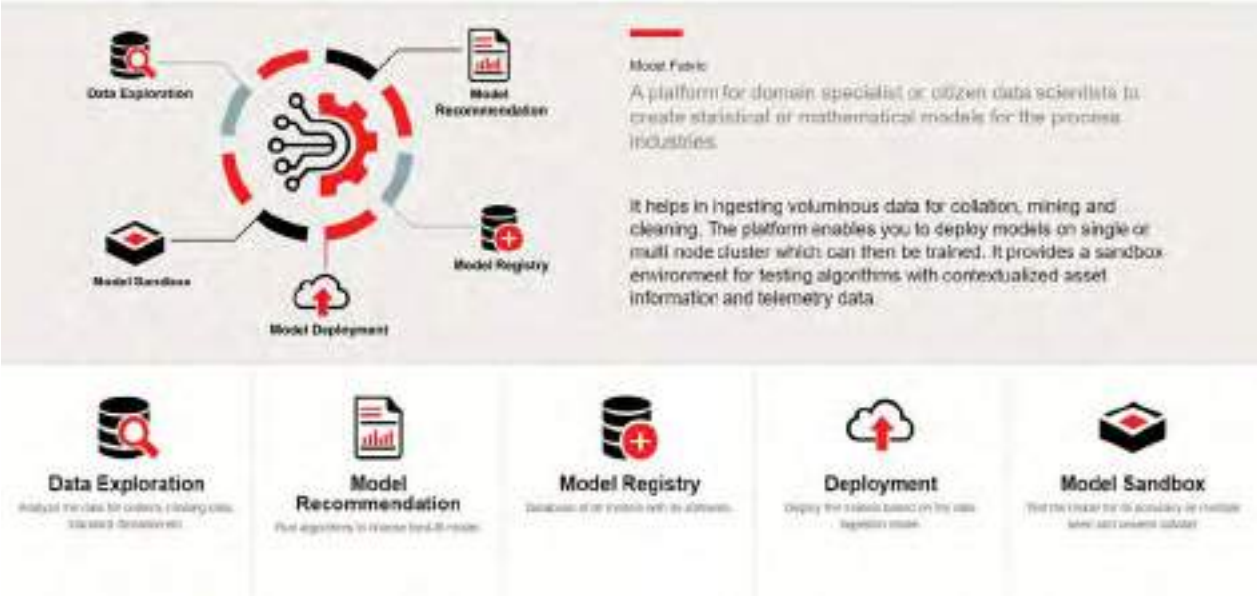
Cognitive Analytics Hub



Industry Cognitive Model

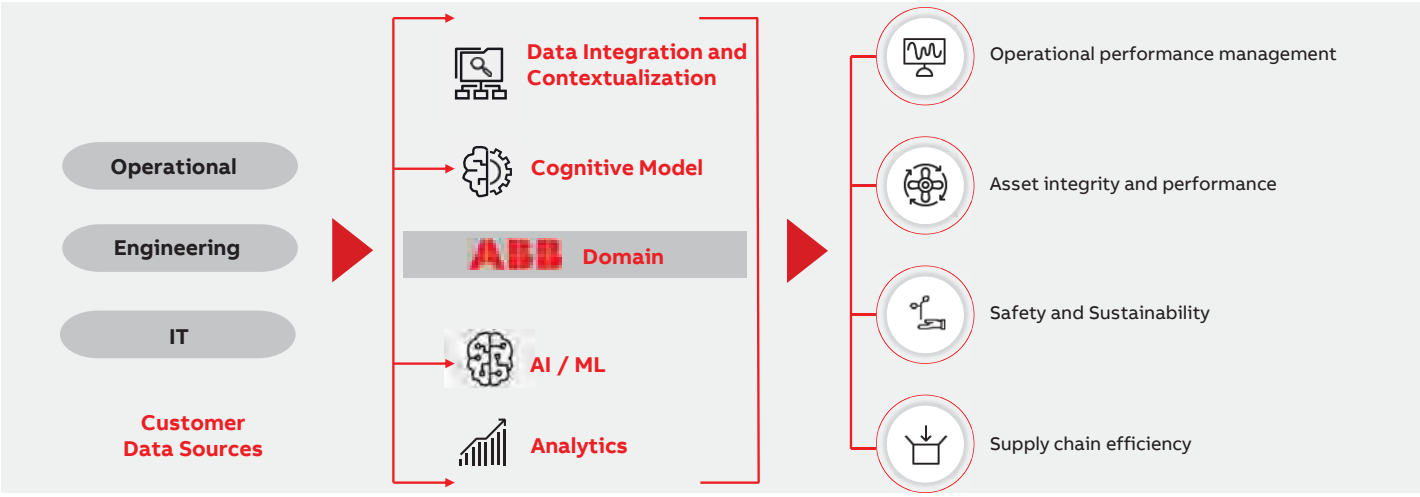
- Deeper cross functional insights
- Pre-built industry rich cognitive model
- Multi-dimensional OLAP. Extensibility framework.
- ISA 95, PPDM, PODS, S88
- Define ready to use analytical models for value applications and dashboards
- Self-service through extensive data elements and business contexts to support creation of KPIs, analytical and AI models, business analytics applications

3. Self Service AI/ML for Domain Specialist in organization



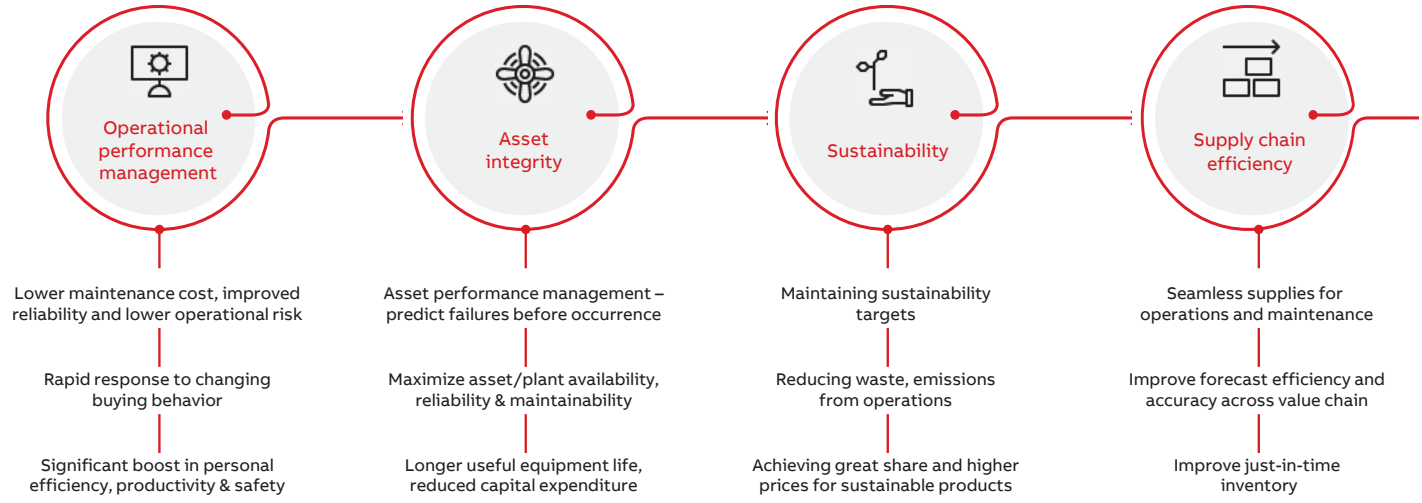
5. Integrated Platform - ABB Ability™ Genix Industrial Analytics and AI Suite

Data, domain, technology and capabilities coming together for maximum impact



Drive direct business outcomes

Addresses operational performance management, asset integrity, sustainability, supply chain efficiency



Increase availability of assets / plants and avoid process upset condition

Avoid system failures by analyzing system operational patterns – System Anomaly Detection

Unscheduled trip reduced by up to 50%

Objective:
- Reduce unscheduled trip
- Increase plant availability
- Avoid process upset condition
- Increase operator response time

Challenges:
- Only 18% of assets have age related failure pattern
- 82% of asset failures occur randomly
- Most random failures of an asset are due to the impact of related assets (ARC data)

Solution:
- Extract data from IT (SAP), OT (OSI-PI) and ET (SPF) data sources with effective streaming of real time telemetry data and automate contextualization
- Add system schematics to provide visual integration of the digital twin
- Detect anomalies based on dynamic operating limits using industry AI model
- Run Performance Curve based analysis to detect deviations

Asset Performance Center

Insights across performance, health, maintenance schedules and asset life cycle cost

Holistic asset insight

Customer value

- Combined and contextualized OT/ET/IT data
- Parameterized Asset templates with pre-built performance models
- Integrity management with compliance to strategy
- Life cycle costing with availability and reliability measures
- Comprehensive dashboards with preconfigured maintenance KPI

Target audience

Maintenance engineer/manager, reliability engineer, operation manager, SME

Solution description

Asset Performance provides functionality for a holistic asset visualization and analysis based on operational, constructional, derived and predicted parameters as well as standard asset KPIs related to asset performance, health, maintenance schedules and asset life cycle cost.

Charts for asset failure metrics

ABB

Predictive Maintenance Center

Increase uptime and prevent failures of critical assets

Advanced fault prediction

Customer value

- Configurable Asset Model Library with pre-built dominant failure modes
- Self-service sandbox to configure rule based or AI/ML algorithms to detect and diagnose incipient failures
- Comprehensive workplace for asset fault monitoring with recommendation

Target audience

Reliability engineer/ manager, SME, Maintenance engineer, Integrity engineer/ manager.

Solution characteristics:

Predictive Maintenance Center provides advanced fault prediction using customized rule based or AI/ML based asset models including recommendations, visualization, and events management.

Asset Life Assessment

Understand expected asset lives and maintenance needs

Asset life and investment planning

Customer value

- Defining damage mechanisms and associated failure scenarios
- Tracking of integrity parameters (like thickness) using manual data capture.
- Qualitative Risk analysis of failure scenarios against different risk categories.
- Optimum blend of maintenance / replacement spend with CAPEX profiling.

Target audience

Reliability engineer/ manager, maintenance manager, Integrity engineer/ manager, Operation engineer

Solution characteristics

Asset Life Assessment provides detailed assessment opportunities by analyzing history of the equipment in different perspectives such as design history, operational history, maintenance history, to generate a plan for asset replacement or life extension.

Title: Digitizing Process Plants using AI and ML Technologies to Enhance Sustainability

Author:

Poonam Parmar Thorave
Marketing and OEM Leader,
Emerson Automation Solutions, India

Abstract:

One challenge all industries have in common is data silos. Different areas or departments in the plant looking at different condition or process indicators to set their own priorities. Sometimes they are focused on the same problem, but do not have the complete information to quickly identify the root cause of the problem. And that's just within one facility - the same silos can exist across the enterprise. How will the different areas - and locations - in your company share in achieving business goals when they aren't sharing the same information?

Data driven approach towards digital transformation refers to the unprecedented disruptions in society, industry, and organizations stimulated by advances in digital technologies such as artificial intelligence (AI), machine learning (ML), big data analytics, cloud computing, Internet of Things (IoT) and the Industrial Internet of Things (IIoT). An enterprise level approach can help provide a holistic overview of the performance and provide key insights to various performance parameters through a single digital interface.

The digital transformation roadmap for process plants can also help to enhance environmental sustainability to a great extent. It identifies the disruptions driven by digital transformation in the environmental sustainability domain through a framework that outlines the transformations by various key performance indicators, like sustainable production, emissions, reliable processes, and energy efficiency. It also involves understanding the organizational capabilities, performances, the corporate digital transformation strategy, customer expectations and environmental sustainability initiatives. Further looking at the present state, the world is working to contain the Covid-

19 pandemic, it has pushed companies over the technology tipping point and transformed businesses forever to achieve sustainable growth. To grow and succeed in a post-COVID-19 world, swift digital transformation for a “pandemic-proof organizational model” is vital. Digital Transformation offers opportunities to realign our businesses around the customer and to create a truly connected and highly profitable enterprise. Unplanned outages result in excessive maintenance, repair and equipment replacement, unsafe scenarios, and compliance risk. According to industry benchmarks, bottom-quartile companies spend nearly four times as much on maintenance costs as Top Quartile performers that leverage the power of predictive intelligence based on AI and ML technologies. Newer ways to be connected to process plant through remote monitoring technologies, predictive intelligence, artificial intelligence, machine learning, personified inputs, would help to deliver decisive advances in customer experience, operational efficiency and competitive edge. Companies are dramatically improving the speed and accuracy of decision-making and actions based on having the right information in the hands of the right expert…no matter where they sit. The industrial internet of things (IIoT) is ushering a digital transformation that enables companies to exploit technology and expertise better than ever before, but only if the right scalable technology strategy is matched to your business goals. Digital transformation should drive positive outcomes: whether it’s streamlining processes, harnessing data or shaping entirely new ways of doing business, this is about uniting every part of the enterprise in a common purpose to achieve a sustainable growth.

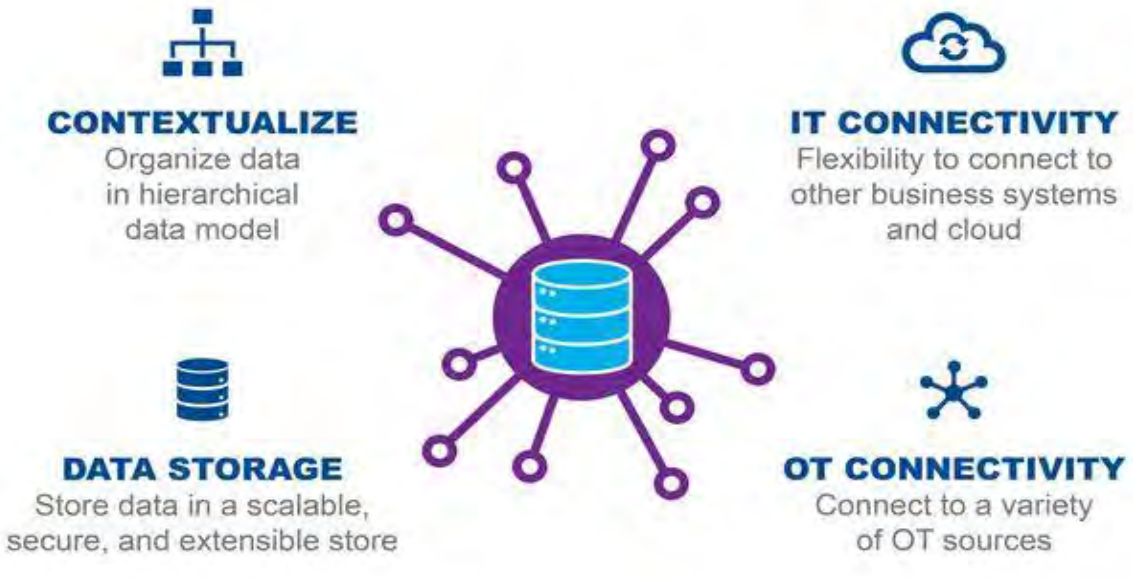


Fig: 1 – Infrastructure needed to facilitate a digital transformation

Keywords:

Digital Transformation, Environmental Sustainability, Decarbonization, Artificial Intelligence, Machine Learning, Big Data Analytics, Internet of Things, Industrial Internet of Things, Business Strategy and Corporate Programs

1. The Impact of Digital Transformation on Environmental Sustainability:

In the manufacturing and energy industries, new challenges are pushing managers to optimize and improve operational efficiency. From the obvious challenge of managing a finite resource to the ever-changing environmental regulations and the competitive pressures, it is easy to understand why industry leaders are continually striving to find ways to maximize productivity. In order to sustain the performance and profitability of their plant operations, they have to make informed decisions which are dependent on the ever-increasing massive amount of data scattered in many sources. The efforts of collecting, cleaning, aggregating and analyzing such data is laborious without the guarantee of any results. To address this challenge, predictive analytical tools like the, Plantweb Optics Analytics Modeling Studio takes away the burden of processing millions and trillions of data measurements such as sensor readings, lab data, simple and complex events, and automatically extract knowledge and predictive models, identify optimization opportunities and behavioral patterns. These digital technologies embedded on artificial intelligence (AI), machine learning (ML), big data analytics, mobile technologies, IoT, and social platforms generate positive improvements for society and industry. Digital technologies are also increasingly deployed in improving environmental sustainability. Companies are now introducing new products and platforms based on digital technologies used to ameliorate environmental sustainability.

Fig: 2 - Transform Data into Knowledge and Profits

1.1 Industrial Energy and Emissions:

Stable utility operations are needed to support all production. Energy is a large part of operating costs for any process/ manufacturing plant and emissions constraints are constantly increasing. It is important to deploy right energy solutions to achieve reliable and responsive performance, improve efficiency, maximize low-cost fuel use, and lower emissions… all at the same time. Energy management solutions to look at all the energy streams, i.e. water, air, gas, electricity and steam (W.A.G.E.S.) would lead to substantial energy savings, taping faulty/leaking steam traps, critical asset health monitoring for energy intensive equipment's, like boilers, chillers, turbines, heat exchangers, provide major energy saving opportunities. Digital transformation offers a suite of solutions and products to meet the specific pain areas related to industrial energy. Key actions to improve sustainability would be by tracking energy consumption, leakages through digital

analytical platforms based on AI and ML, monitoring specific energy intensive equipment/processes, minimizing energy losses, creating awareness on energy savings, establishing an energy management plan and assigning a team to execute the plan, enabling compliance to ISO 50001, worldwide energy standards and deploy scalable solution with a tiered approach to maximize energy efficiency investments.

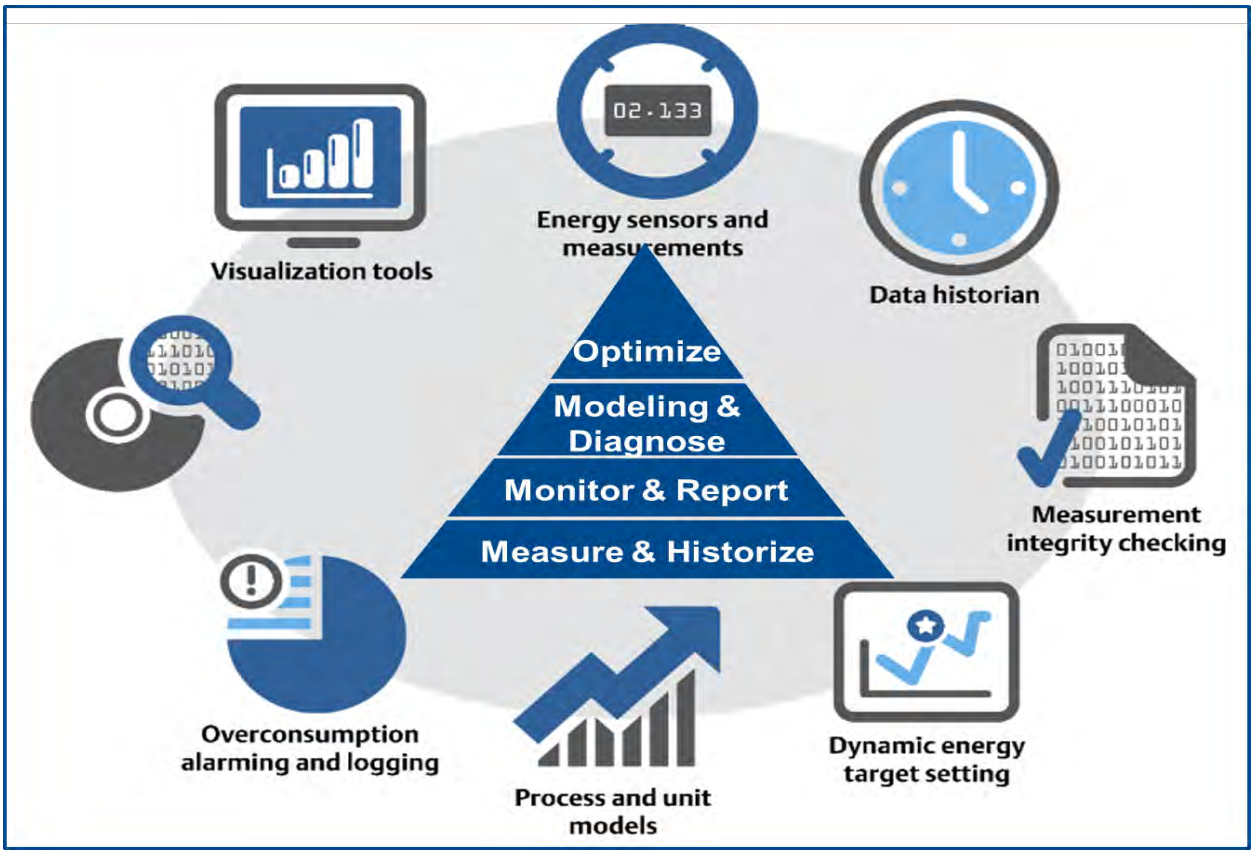


Fig: 3 – Energy Management Plan and Digital Predictive Analytic Systems

1.2 Predictive Analytics Software Platform:

Predictive Analytics software using artificial intelligence (AI) and machine learning technologies (ML) play an important role across these environmental sustainability efforts. For example, Emerson's Plantweb Optics™ Analytics software — part of Emerson Plantweb™ digital ecosystem and recognized as the 2021 Analytics Platform of the Year' at the IoT Breakthrough Awards – uses artificial intelligence and machine learning to

improve reliability and safety and to reduce energy use, GHG emissions and material waste, while optimizing production for industrial manufacturers. Emerson also introduced augmented reality (AR) technology for Plantweb Optics, enabling workers with enhanced access to critical information and expert guidance as well as empowering remote collaboration to maintain operations and prevent downtime.

The predictive analytics platform connects data from multiple applications into asset-centric information to deliver persona-based alerts and KPIs for production assets. These applications are used to monitor, analyze, diagnose, and provide real time alerts of critical equipments, instruments, and valves for improved decision making. Organize consulting services for audits and process modifications.

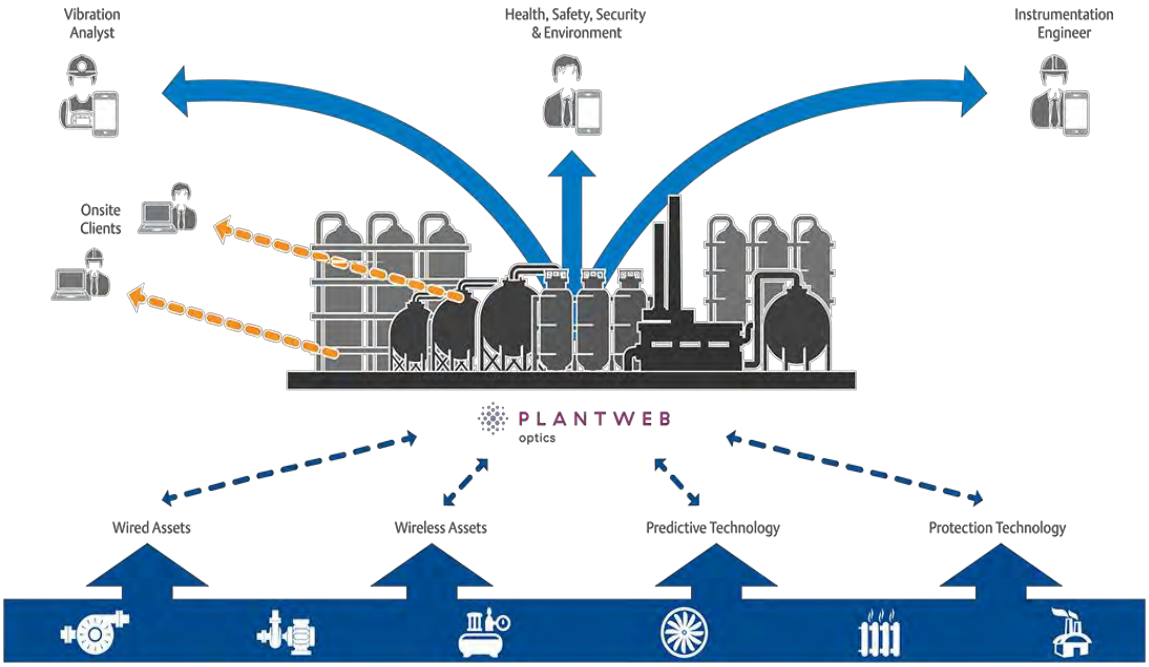


Fig: 4 – Predictive Analytics Software Platform

Conclusion:

Digital solutions are required to access the information needed to effectively manage the performance of a process or an equipment. Data from predictive intelligence applications and analytical tools are aggregated to create a holistic picture of the processes. Utilize optimal package designs and ensure machines run at centerline for less waste and

scrappage. Automatic and real time data alerts are a straightforward way to understand what is happening at a glance. Communication tools allow personnel to collaborate on developing production issues while accessing data necessary to drive decisions. Making this information available anytime and from anywhere enables personnel to prevent potential failures.

Emerson's Plantweb digital ecosystem is a scalable and secure portfolio of transformational technologies, software, and services that provide relevant personnel with enhanced insight to enable actions that drive operational excellence. Plantweb Optics Analytics is an out of the-box process data analytics software that allows end users without extensive domain expertise to:

- Inspect, clean and transform raw data into information and knowledge.
- Create predictive models that can be deployed in real time.
- Eliminate erroneous data and pinpoint problem areas.
- Perform proactive decision making to prevent abnormal conditions and identify opportunities.
- Recognize behavioral patterns and correlate data with events.

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Comprehensive Early Warning System in Hydro Power Projects located very close to glaciers in Himalayas

(Sumit Kumar Haldar, Gunjan Tandon, Praveen Kumar Gupta)

NTPC Ltd.

Abstract

This paper intends to briefly explain the disaster which took place on 07th February, 2021 at Chamoli, district of Uttarakhand which completely routed out the Rishiganga Hydel Power Project and caused severe damages to the barrage of NTPC's Tapovan Vishnugad HPP leading to an irreparable loss of life and property. It also aims to assess the strategies for early disaster forecasting and warning dissemination which can effectively prevent loss of precious human life due to similar such events in the future. This paper aims to present and discuss available technologies which can be leveraged to design a holistic solution that can be deployed for a complete online continuous monitoring of the upstream catchment area of these Hydro Power projects.

1. Introduction

On 7th February, 2021, a deluge event got originated due to a large ice/ snow/ rock avalanche occurring in the high altitude areas, primarily because of a wedge failure in highly jointed rockmass in Ronti Gad, a left bank tributary of Rishiganga river. The ice/ snow/ rock avalanche generated a huge debris flow, also formed an artificial dam in between on Rishiganga near its confluence with Ronti Gad and caused severe inundation in the downstream areas in Rishiganga-Dhauliganga basin. The photograph indicated below shows a clear scar in the Nandaghunti Mountain at the starting point of glacial debris flow. The analysis of satellite imagery, seismic records, numerical model results and eyewitness videos reveals that ~$27x10^6$ m^3 of rock and glacier ice collapsed from the steep north fact of Ronti peak. The rock and ice avalanche rapidly transformed into an extraordinarily large and mobile debris flow that transported boulders greater than 20m in diameter and scoured the valley walls upto 220 m above the valley floor. The intersection of the hazard cascade with down valley infrastructure resulted in a disaster, which highlights key questions about adequate monitoring and necessity of an Early Warning System in the Himalayas.

Figure: 1.1

2. Probable causes leading to the rock slide: (ref. Arun B Shrestha et al., Understanding the Chamoli flood: Cause, process, impacts and context of rapid infrastructure development, 03rd Mar, 2021, River Basins and Cryosphere, ICIMOD):

I. **Precedent weather conditions:** A strong western disturbance passed across Kashmir and northwest India from 4 to 6 February 2021. It was fully charged with convective instability that may have contributed to the heavy precipitation.

II. **Climate change:** Maximum temperature in the Chamoli area has increased at the rate of 0.032ºC per year between 1980 and 2018 which is statistically significant at 99.9% confidence level, compared to minimum temperature which has increased at 0.024ºC per year at 90% confidence level. Furthermore, January 2021 was the warmest January on record in Uttarakhand for six decades.

III. **Other factors:** At the same headwall, a large ice avalanche was previously released somewhere between 19 September and 9 October 2016, which deposited ~1.5 x 10^7 m^3 of ice and more bedrock in the valley below. The resulting destabilization of the rock due to the lack of ice cover (glacial de-buttressing, stress-release fracturing), and increased exposure to solar radiation and hence an increased freeze thaw cycle, in combination with a large snowfall event preceding the event of 7 February 2021 and rapid melt water production, may have led to the fracturing of rock.

3. Planning, Mitigation, Preparedness, Response and Recovery:

Efficient management of disasters, rather than mere response to their occurrence has in recent times received increased attention. Holistic management of disaster calls for assigning priority in the prevention, mitigation and preparedness activities in the pre-disaster scenario.

Advances in Remote Sensing, high precision imagery, Geographical Information Systems (GIS), Geodetic Sensors, Positional intelligence and Artificial Intelligence (AI) have made it possible to not only forecast some of the disasters but also to have made available means, for quick and effective rescue and relief operation, thereby minimizing the deadly impacts of some of the worst disasters. Revolutionary advances in the areas of communication, remote sensing, modelling, real-time sensor integration and simulation capabilities on a Geographic Information Systems (GIS) platform are leading to a paradigm shift in disaster management information system.

Instead of traditional response centric approach for disaster management, utilizing multi-services viz. voice, data and video, through a dedicated and reliable communication network, emphasis is now shifted to provide knowledge-based information to all the stakeholders for a holistic management of disaster in a pro-active manner, assigning priority to the pre-event scenarios of prevention, mitigation and preparedness program to ensure faster and more efficient rescue and relief operations during the emergency and to build better strategies, in the post-event scenario leading to disaster resilience in the society (which is essential for the sustainability of the development efforts).

4. Early Disaster Warning System:

In an emergency, response time is critical. Gaining rapid access to pre-event data, analyzing the current situation on the ground, identifying the most critical areas in need of attention and then communicating cross-agency to all responders ensures the best use of available resources in the recovery effort. The unpredictable nature of disasters necessitates that administration always be prepared for the worst. A significant degree of that preparation lies in the ability to have complete coordination and communication solutions. Innovation is the key to such solution.

A perfect amalgamation of sensors, software, domain knowledge and relevant workflows into intelligent information ecosystems deliver actionable information is the key to success.

Provision shall be there to capture constant real time changes in the geography through satellite imagery, terrestrial and aerial photography, remote sensing, CAD and GIS, transforming raw geospatial data into relevant information.

5. Probable Solutions for holistic monitoring of upstream catchment area:

1. Geotechnical Sensor based monitoring
2. Avalanche, Slope monitoring & Landslide monitoring
3. Aerial imaging using Drones
4. Satellite Image Processing and Analysis
5. GIS based image analysis and mapping, spatial modelling/analysis
6. Flood analysis and simulation
7. Subsidence monitoring and predictive analysis
8. Glacial lakes and Stream monitoring
9. Integrated Command and Control System
10. Mass Communication for Warning Dissemination

5.1 Geotechnical Sensors: Geotechnical sensors measure non-georeferenced displacements or movements and related environmental effects or conditions.

- Extensometers, piezometers, inclinometers / tiltmeters, Thermometers, barometers
- precipitation (rain, hail, snow), Automatic weather station (AWS), Automatic Water Level Recorder, Seismic Sensors

These are very essential for assessing the effect of weather and other environmental conditions on the various natural calamities and the extent to which they are influenced.

5.2 Avalanche, Slope and Landslide monitoring: Radar based monitoring is essential to predicting the behavior of structures, since monitoring can detect when movements can become catastrophic for the stability of overall structure. Continuous information from up-to-the-minute or real-time monitoring provides prompt notification of activity, advances our understanding of

landslide behavior and enables more effective engineering and planning efforts. Near-real-time monitoring of active landslides or landslide-prone hillslopes can provide immediate notification of landslide activity, as well as high-quality data sets for understanding the initiation and movement of landslides.

The avalanche radar is a device for automatic detection and tracking of avalanches. The radar permanently scans the targeted slope for avalanche release. Once the radar detects an avalanche, it tracks the avalanche's path and size. Avalanche characteristics are transmitted to an online data portal and the avalanche can be shown on an area map. Integrated cameras record videos of the event. Additionally, remote camera access is available via the online data portal, allowing for convenient and quick inspection of the area. The avalanche radar can be linked to an alarm system enabling automatic traffic control measures, for example road closures.

The two avalanche radars with thermal and PTZ cameras and communication devices.

Figure: 5.2.1

Radar is particularly suitable for the detection of avalanches and has several advantages over other technologies, particularly the ability to work in all-weather and at any time. Radar sees through snow and fog day and night. In addition, radar operates at distance and thus permits large areas to be monitored without the need to install instruments in dangerous zones (such as geophones). With a maximum range of 5 km, slopes of up to 10 km^2 can be monitored with a single radar.

In order to guarantee the area of interest is visible by the radar (and to maximize the scannable area), careful selection of the radar location is vital. Initially, potential radar positions are simulated by using a digital terrain model. Appropriate radar locations are then assessed by simulating the radar's view and range from the proposed positions. Along with the view criteria, the position must consider electricity and communication availability. If required, alternatives for electrical power supply and communication can be provided (e.g. fuel cells, solar power or radio).

A PTZ-camera (Pan-Tilt-Zoom) installed on the radar mast observes the slope and automatically records the detected avalanches. In the case of an alarm system, additional cameras are mounted in the area at risk (e.g. on the barriers or traffic lights) for automatic event recording and remote inspection at any time (e.g. after an avalanche).

5.3 UAV and Aerial Imaging in Disaster Assessment: Aerial views are critically helpful in large-scale disaster zones. Drones, designed to be agile, fast and robust, empower response teams with a substantial upper hand without costing as much as manned flight operations. Since they are autonomously flown, drones can access hard-to-reach areas and perform data-gathering tasks that are otherwise unsafe or impossible for humans.

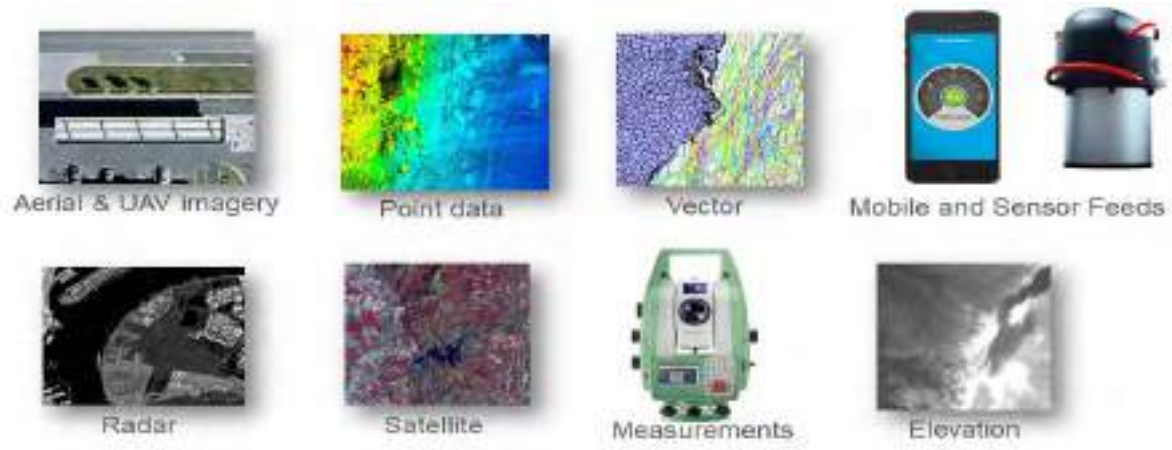

Figure: 5.3.1

5.4 Satellite Image Processing and Analysis: Satellite imagery is very effective for monitoring major natural disasters, both before and after an event. Remote sensing satellites offer the benefit of collecting imagery from space over large geographic areas, without endangering people on the ground. There are many factors to consider, including resolution, spectral bands and temporal frequency. Some satellites can be tasked to acquire sub-meter

imagery of a specific area every one to two days, while others offer continuous coverage of the same area at lower resolution. Synthetic aperture radar (SAR) collects data day and night through any weather condition, while the shortwave infrared (SWIR) band of an optical sensor "sees" hot spots of a wildfire through smoke. A combination of imagery, such as SAR, SWIR, and natural color (called RGB after the red-green-blue visible bands), collected before, during, and after an event and viewed with layers of GIS data (roads, utilities, schools, hospitals, etc.) provides the most complete picture.

5.5 GIS based Image Analysis and Spatial Modelling: Timely information on the occurrence, progression and regression of disasters during the various phases are essential for effective management of disasters and this can be derived by integrating the real-time imageries, sensors, with ground information on a Geographic Information System (GIS) platform. By integrating context of location with socio-economic and demographic attributes, Geospatial and Geosystem technologies offer organizations an unified platform with power to see, power to visualize, power to detect, power to assess and power to respond, while at the same time help eliminate redundancy and optimize technology investments. The obvious advantage is availability of real-time information offering a common operational picture and enhancing situational awareness.

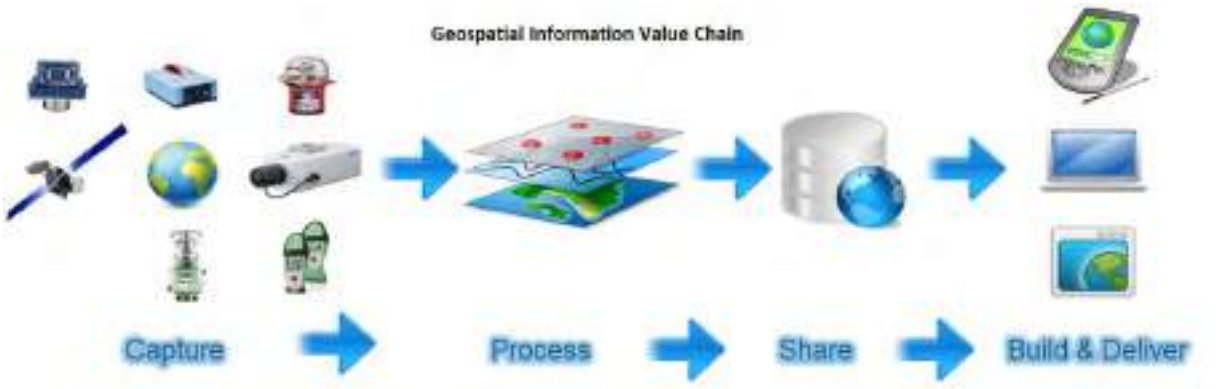

Figure: 5.5.1

GIS information plays a critical role in all phases of disaster management including disaster recovery and can shed light on many key activities. Emergency management operations during disasters fundamentally depend on location information to successfully manage and respond to serious and urgent situations. This help to lessen the impact across all phases of disaster management. Rapidly authoring, fusing, analyzing, managing, and delivering data is crucial for up-to-date situational awareness and response and recovery efforts.

GIS is one of the most important tools utilities need when responding to a major disaster: centralized, readily available, highly accurate spatial information. Utilities employ GIS in large part to simplify data management and improve the availability of accurate asset and network information.

As opposed to legacy computer-aided design mapping systems, where information was stored largely on paper maps making it virtually impossible to maintain and share an accurate picture of the network across the organization, GIS allows information to be centrally managed and shared across the entire organization in real-time. Whether in the executive suite or the field truck, users can access the network and be confident they are viewing accurate and up-to-date information.

5.6 Flood Analysis and Simulation: Given the increase in extreme weather events, climate change and topology, majority of the geographical events in the Tapovan region lead to floods and flash floods and being able to model and predict locations that might be most impacted becomes increasingly important. Identifying areas of land which, while not normally inundated with still or moving water are most prone to retaining water as it passes through a catchment area and becomes waterlogged or flooded.

Using various commercially available Spatial Modelers, a model can be constructed to measure the Terrain Wetness Indicator. This wetness indicator (WI) is a means of measuring drainage or drainage potential in a landscape, identifying areas where water will either pool or runoff water will slow significantly. The process identifies where elevation changes are less than surrounding areas and where flow routes may be somewhat inhibited. WI areas are exclusive of permanent water bodies and wetlands but may provide significant storage and contribution to these areas.

Executing the model using an input Digital Elevation Model (DEM) can help relief experts predict areas prone to water logging during an extreme weather event, even if they are not areas traditionally subject to flooding when a river bursts its banks. This wetness indicator (WI) is a means of measuring drainage or drainage potential in a landscape, identifying areas where water will either pool or runoff will slow significantly. The process identifies where elevation changes are less than surrounding areas and where flow routes may be somewhat inhibited. WI areas are exclusive of permanent water bodies and wetlands but may provide significant storage and contribution to these areas.

5.7 Subsidence Monitoring and Predictive Analysis: Subsidence is a Global challenge. Monitoring of the Earth's surface and infrastructures' stability is a key activity to ensure people's safety, environmental protection and the safeguarding of assets at all stages of the life cycle of infrastructures, from design to production, management and maintenance.

All kinds of surveys and inspections happens only when the disaster occur just because so far there is no operational system in place on ground which gives a hint about what to inspect and when. Because of this non-linearity an indefinite cost and timeline gets associated with the surveillance. And most importantly periodic monitoring of remote areas becomes almost impossible because of tough terrain and lack of manpower but most of these areas contain vital infrastructures like Railway tracks and roads.

Satellite monitoring allows to overcome these limits, reaching high frequency, precise and accurate actionable information thanks to the ever-increasing availability of open data. Some newly developed technologies like Persistent Scatterer Interferometric Synthetic Aperture Radar for Subsidence Mapping can act as a game changer.

• A Scatterer gives a strong radar return – such as a metal roof, power pole, or some big boulder in the countryside

• Persistent -- always there, always strong, always appears in image after image – over a long period of time, even over years. We can look at and monitor movements of these same persistent scatterer objects, those same points, in image after image over periods of time. The technology we use is Interferometry, which means we are looking at the interference pattern of the phase of the radar signal.

It has got very precise science and mathematics behind this technology. When motion is monitored using a satellite in space then the same is done in all 3 dimensions – not only monitoring subsidence and inflation, we also have north, south, east and west direction, so it's multidimensional displacement.

5.8 Glacial Lakes and Stream Monitoring: Self sustainable geotechnical sensors are required to be installed for measuring lake levels and river station for measuring discharge flow rates. Pressure sensors and seismic sensors are used for measuring water level of lakes at the lake ground and radar type level transmitters and surface velocity transmitters are to be mounted across the rivers to measure level and flow. Computer vision techniques via CCTV images, IR

cameras become extremely handy for remote monitoring of these very remote glacial lakes and streams.

Data communication and self-sustainable power supply solutions are the key to continuous monitoring of these most inhospitable areas through the use of modern technology.

5.9 Integrated command & Control center / Emergency Operation Center: The Integrated Command & Control system enables a fast, well-orchestrated response that mitigates harm, helps maintain order and control events quickly once they occur. The solution improves multi-agency coordination that simplifies cross-agency communications and enhances situational awareness with a common operating picture available to all authorized users.

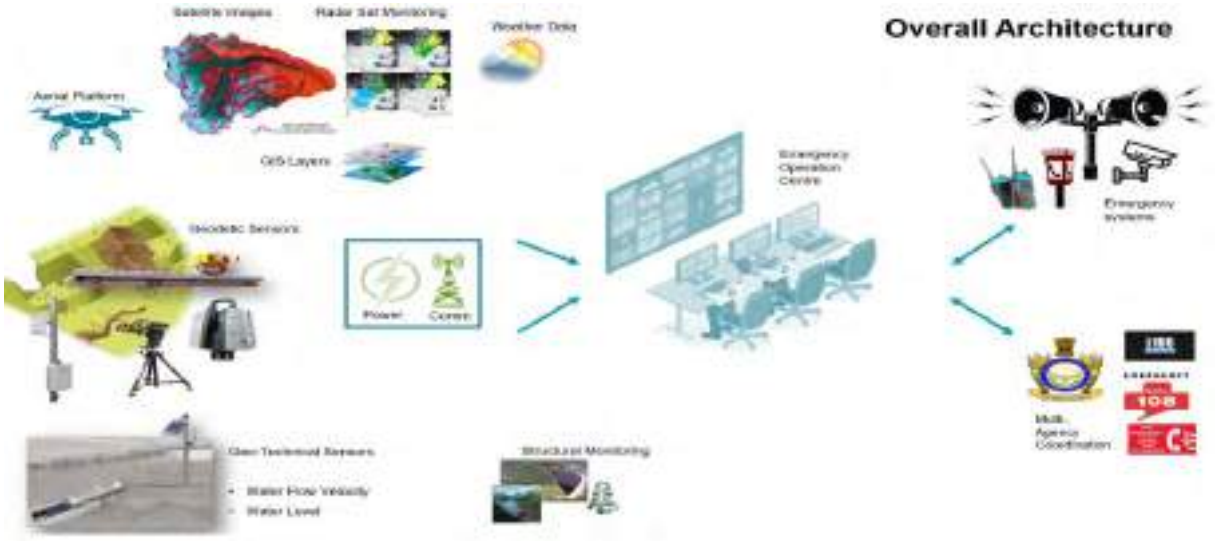

Figure: 5.9.1

5.10 Mass Communication for Early Disaster Warning Dissemination: To provide state of the art & highly reliable Last Mile Connectivity solution for addressing in disaster management and disaster relief in very short time and also to define the operational model and implementation characteristics that can be used for addressing the disaster relief, Last Mile Connectivity can be achieved by equipping different Technologies viz. Digital Mobile Radio (DMR), Satellite Phones, Mass Messaging, Alert Tower Siren Systems and Universal communication Interface etc. at strategic locations in the Hydro Power .

The DMR can be interfaced for secure communications as well as interface with sirens and trigger them to sound alarms. Satellite Network will be able to establish a broadband connection

from a remote site to establish instant access to State and District level officials through Voice, Data and Video.

Media Gateway is proposed to establish inter technology communication between the available technologies which are not damaged by the disaster.

6. Communications: Highly reliable communication networks are essential for transmitting data from various sensor stations to the command and control center. Possible communication systems for the purpose are as follows:

1. **VSAT (Very Small Aperture Terminal) Network:** It works on Geostationary Satellites and employ microwave frequencies between 3.5 and 6.5GHz (C & XC bands) and between 10.5 and 14.5GHz (Ku-band). A VSAT station is made of two separate sets of equipments, viz. the outdoor unit (ODU) and the indoor unit (IDU). The outdoor unit is the VSAT interface to the satellite, while the indoor unit is the interface to the customer's terminals or local area network (LAN).

2. **Point to Point Network:** Terrestrial communication through a point to point network can be established through RF (Radio Frequency) based network on VHF / UBR / NBR. RF based networks can be on the licensed or unlicensed band. This is an independent and dedicated network which requires installation of a large no. of towers of various heights for installing radio sets and repeaters in order to achieve line of sight. A large no. of towers will be required to be installed in the hilly terrain for establishing the network. Further, this will also involve regular maintenance of the towers and other accessories of the network during O&M stage.

3. **Mobile Network (GSM / GPRS):** In this system data is transmitted using mobile phone links with General Switched Messaging (GSM) and General Packet Radio System (GPRS) protocols. This is useful for long-distance communication. This system gives access to the internet through an Internet Service Provider (ISP). Typically in Hydro power projects at the foothills of the Himalayas, GSM / GPRS signals are very weak around the project site as well as in the upstream area where the sensor stations are proposed to be located. Therefore at present GSM / GPRS network cannot be considered as a reliable communication system.

7. Conclusion: In this paper, we tried to provide a broad picture of the various strategies and modern technologies available for monitoring, generating warnings and mitigation to an extent of the devastating effects which are caused by natural calamities and disasters in the Himalayan region, especially in and around run of river Hydro Power Projects in these areas which are strategically located very close huge glaciers.

Use of Computer vision based on Geospatial / aerial image analytics combined with data from various technical and geodetic sensors can be a game changer and can be extremely helpful in understanding the upstream area better for a successful Early Warning System.

8. Scope for Future Work: There is a tremendous scope for extending the base ideas suggested in this paper to develop a concrete strategy of Early Warning System which can be replicated in different Hydro Power Projects. Each suggestive solution is immensely vast and a lot of work is required to be undertaken for making them tailor-made for specific applications. Further, this paper has majorly dealt with latest available technologies for early assessment of impending disasters but there are many strategies involving mechanical measures which can actually reduce the wrath of disastrous events like flash floods, GLOF, LLOF etc. thus saving precious life which will be the scope of study in a separate paper.

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SAFE & OPTIMIZED CLOSED LOOP SAMPLING SOLUTION

Sampling is the science of safely capturing a sample from a process or a pipeline while maintaining the chemical composition during storage or transport for later analysis. Depending on the process phase, temperature, consistency, chemical makeup and other factors, there are a variety of approaches that can be used to extract a sample.

Swagelok employs a team of field engineers throughout the world whose mission is to be the technical liaison and advocate between the customer, our distributor network, and the factory by providing an extension of Swagelok engineering resources. Swagelok's field engineers help customers diagnose sampling system inaccuracies or off-spec products in different industries around the world. They have identified accepted engineering practices that improve the function & safety of closed loop sample systems and retain the quality of the sample taken.

Some of the best design practice which will be discussed during the session are:

- Use Sample Probes at the sample extraction point
- Choosing the right container (bottle/cylinder) based on sample phase.
- Use of tube vs pipe
- Sample flow path for liquid & gas sample
- Utilize appropriate sample cylinder mounting
- Improve Hose life by appropriate selection and position
- Avoid sample cylinder contamination
- Avoid Dead Legs
- Enhance operator safety by utilizing unique switching valve
- Provide appropriate instrumentation
- Use Keyed Quick couplings

SAFE & OPTIMIZED CLOSED LOOP SAMPLING SOLUTION

- Alice Chin
Swagelok Field Engineer - Supervisor

Agenda:

- Sampling Techniques
- Overview of Swagelok Grab Sample Offerings
- Specifying a Grab Sampling System
- Overview- Sampling System
- Sampling Best Practice

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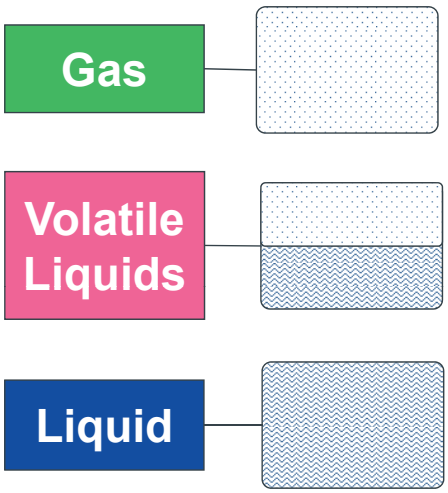
Sampling Techniques for Different Samples

Phases

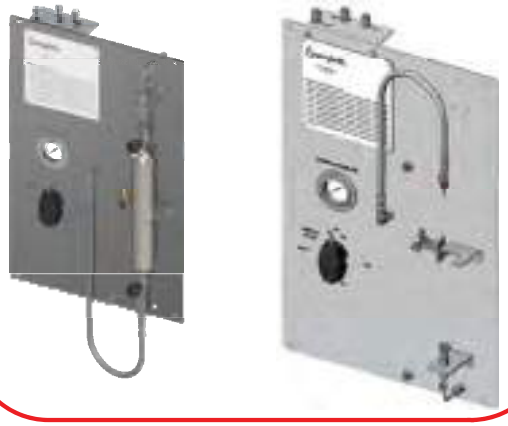


Above Atmospheric Pressures

Atmospheric Pressures
Liquids Only!

Swagelok GSM, GSL and GSC

GSM



GSC

GSL

Samples Under Pressure
Gas, Liquids & Volatile Liquids

Samples are Atmospheric
Liquids Only

Specifying a Grab Sample System– Need to Know

Sample Medium?

- Gas, Liquid or Volatile Liquid?
- Liquid -> sample under pressure or atmospheric?
- Always ask -> *What are you sampling for?* (i.e. looking for traces of Sulphur in Diesel)

Sample Volume?

- Typical – 500ml, 1000ml
- Other volumes available

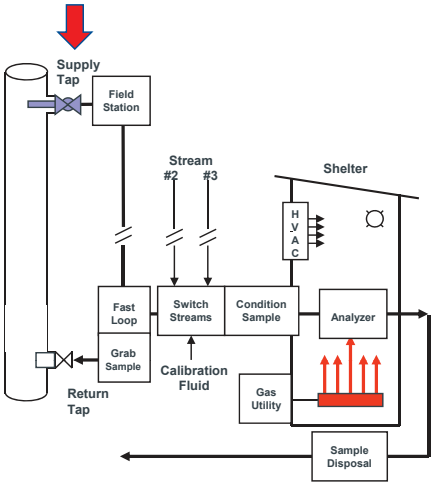
Purge Function?

- Is the medium toxic or hazardous?

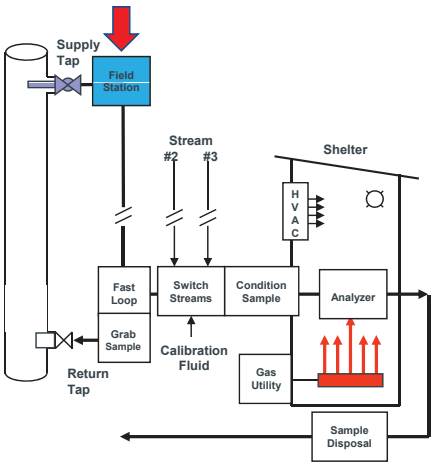
Continuous Flow?

- Determined by the *distance* from the sample tap location
- To get the most accurate sample
- Also known as a built-in fast loop

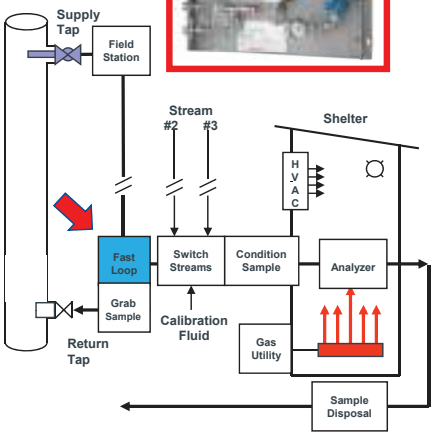
Sample System Basics – Overview



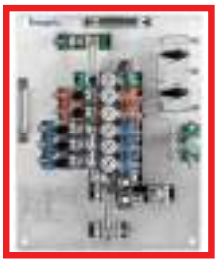
Sample System Basics – Overview

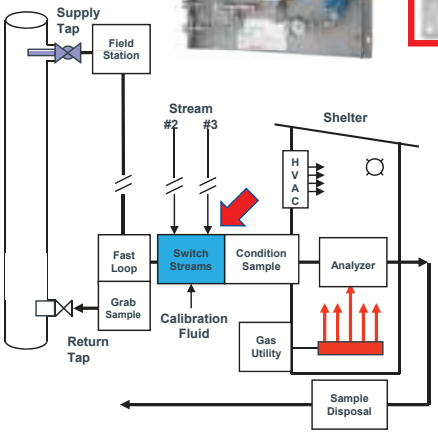


Sample System Basics – Overview

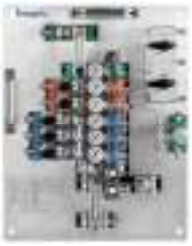


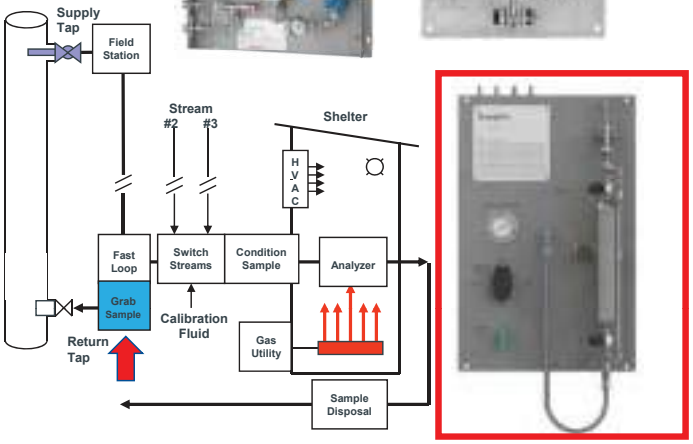
Sample System Basics – Overview





Sample System Basics – Overview

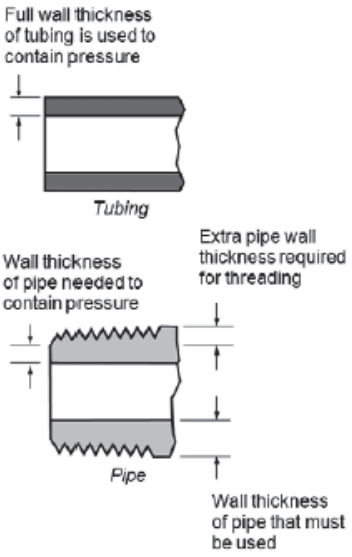




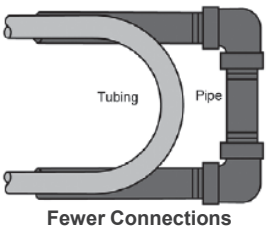
Sampling Best Practices

Advantage of Tube System vs Pipe System

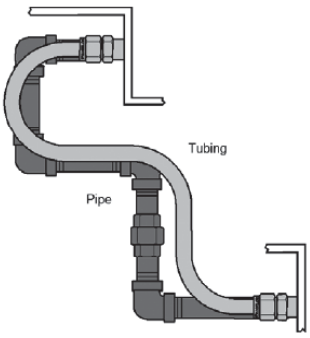
- Ease of Installation & Maintenance
- Better Strength-to-Weight Ratio
- Decrease the number of potential leak points
- Lower Pressure Drop



Better Strength-to-Weight Ratio



Fewer Connections

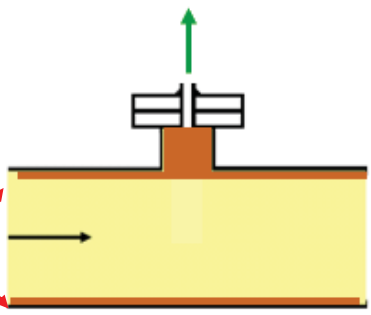


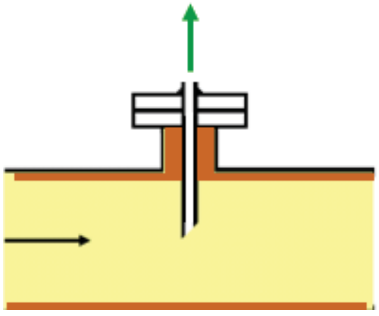
Less Pressure Drop

Benefit of using Probe during Sample Extraction

- Probe provides a faster analyzer response by reducing the volume of the sample system.
- Probes Eliminates extraction of sludge along the pipe walls by sampling from the center of process pipe

What does the inside wall of this pipe look like?


Without Probe


With Probe

Sampling Methods for Liquids and Gas

- Liquids
  - Sample filled from bottom up
  - Ensures cylinder is full and gas phase is flushed
  - Outage tube can be added to provide sufficient vapour space for expansion (*volatile liquids*)

- Gas
  - Sample filled from top down
  - Removes liquid condensate

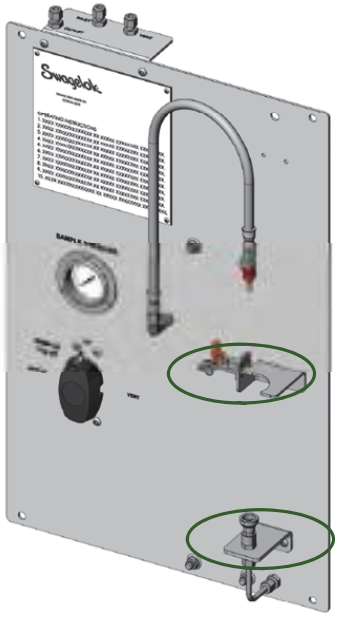
Sample Cylinder Mounting

Concerns

- Sever load on Quick Couplings
- Premature Quick Coupling Failure
- Operator safety hazard

Benefits

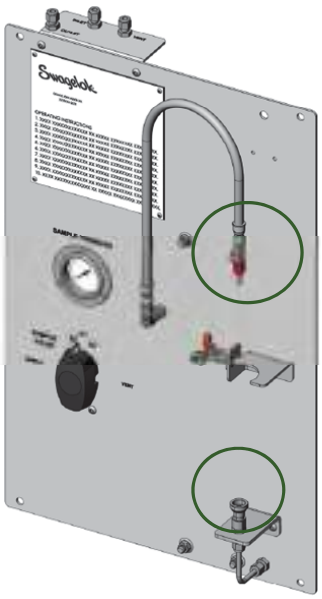
- Load distributed onto brackets/clamps
- Improved operators' safety
- Increase the life of Quick Coupling



Keyed Quick Connects

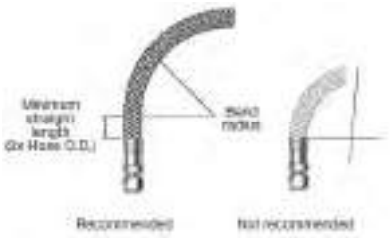
- Provide a positive mechanical lockout
- Prevent accidental intermixing

Key Color	Key Number and Designator
Black	K1
Orange	K2
Green	K3
Yellow	K4
Blue	K5
White	K6
Purple	K7
Brown	K8

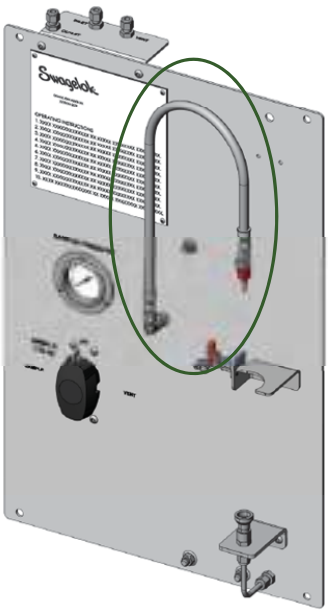


Improve Hose Service Life

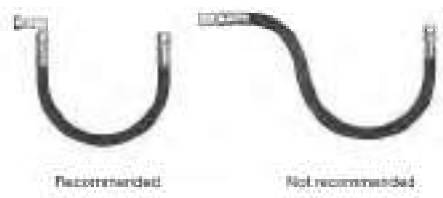
- Maintain minimum Bend Radius
- Hose Length
- Hose Strain
- Avoid Kinking



Minimum Bend Radius

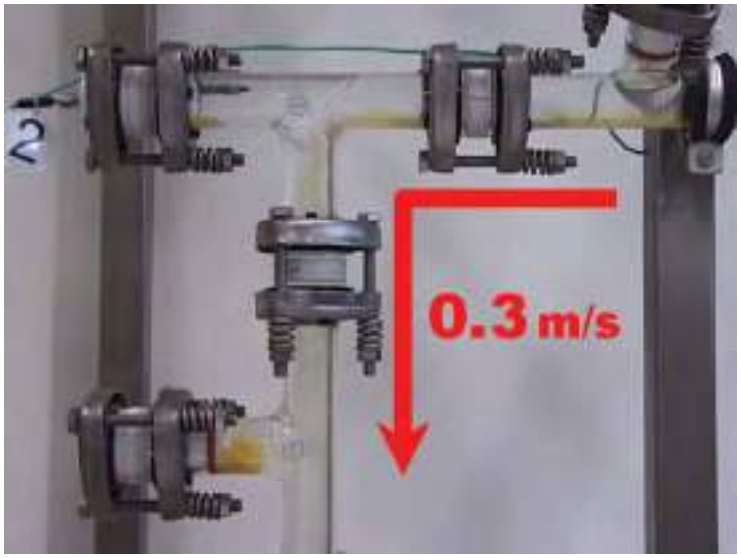


Kinked Hose



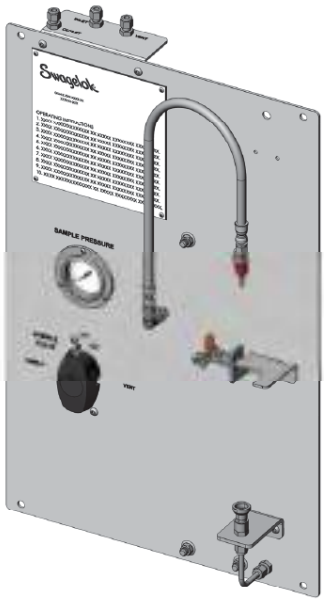
Hose Strain

Dead Legs in Action



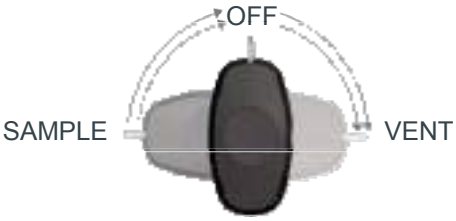
Link:[19] https://www.youtube.com/watch?v=vWn4QBjtFxY

Safe and Ease of Operations



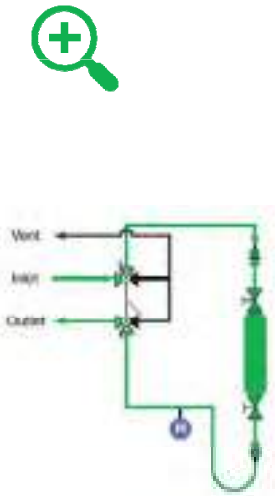
- **Safety!**
- Single valve operation ensures there is no actuation of the wrong valve during sampling
- Fool-proof operation – no second guessing what the panel is doing – clear indication of the sampling mode

Valve Gearbox Assemblies



- Handle positions
- Sample
- Bypass
- Vent

Problems? Gas Application Possible Solution:



Session – 5

Ethernet- APL for Process Automation

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Currently employed as Sales Specialist - Automation at Pepperl & Fuchs India Pvt Ltd.
He is assigned with the responsibilities of Process Automation markets involving Fieldbus, Remote IO, HMI, Purge, Interface and Wireless technology products for the Indian Market.
Unnikrishnan R is having Bachelor's Degree in Electronics and Communication. He is working as Sales Specialist taking care of various technical and sales activities for the past eleven years with Pepperl & Fuchs - India. He is having 19 years of industrial experience.
Unnikrishnan is an Active Member of FF Society India. He involves in various Technology Promotion activities. He has also conducted many trainings on Explosion Protection, Fieldbus technology, WirelessHART, Industry 4.0 , Ethernet-APL across India.

Digitalisation is a top priority for process plant companies and getting it right brings outsized opportunities for profitability and growth.The digital agenda of Pepperl + Fuchs is all about tackling digitalization, while simultaneously working towards the company's growth targets. Pepperl + Fuchs' Digital Agenda deals with digitalization in four major categories: Smart Business Processes, Smart Production Processes, Smart Products, Connectivity, Services and Smart Collaboration, Standardization.

Industry 4.0 – the 4th revolution is the current trend of automation and data exchange. It includes cyber physical system (CPS), the internet of things, cloud computing, cognitive computing and artificial intelligence. The industrial internet creates higher production and resource efficiency.

Ethernet to the Field or Ethernet Advanced Physical Layer (APL) is a vision driven by new technological developments, in order to turn concepts like Industry 4.0 and the Industrial Internet of Things into a reality.

The Advanced Physical Layer (APL) or Ethernet to field is the largest collaboration effort in the field of process automation.

Ethernet in the field of process automation is highly desired by many stakeholders in process industries. Let us introduce terminology and concepts that will make clear why is this the case.

Ethernet is the physical layer of devices that are directly connected with each other. It includes addressing information.

Ethernet communication is defined in layers.

For example: The IP address of your smartphone or laptop is part of the network layer 3. Layer 3 does not have to know about the other layers. When you connect your device via WIFI, the network layer communicates the IP address over the air. Similarly when you plug in your Ethernet connector at home or office: a wire is used. The network layer with the IP address neither knows nor cares. It just makes the connection via layers 1 and 2 that are available.

The wires and electrical signals are defined in layer 1. This is the physical layer. APL defines this physical layer with the special properties for the field of process automation and without any influence on other communication layers.

As a result, any type of communication over Ethernet can communicate via APL without any issues.

Ethernet APL is just a physical layer.
APL will make it possible to connect field devices directly to Ethernet-based systems and the network transitions that up to now have presented timeconsuming configuration bottlenecks will no longer be required.

Functions and Features of Ethernet APL
• Ethernet-based, for any protocol or application
• Power and data over a shielded twisted pair line
• Any method of hazardous area protection especially intrinsic safety, including simple validation
• Transparent connection to any IT network
• Re-use of existing two-wire cable
• Supports the familiar trunk-and-spur-topology
• Device access anytime and anywhere
• Fast and efficient communications for automation and other applications

The Industrial Internet of Things takes shape in process plants also.

The industrial internet of things looks to harness sensor data of the installed base. This is based on the belief that machines with artificial intelligence and lots of data can spot problems sooner for better decision making.

IIoT essentially defines the infrastructure and data access on which applications then can be built. They reside at the top layer and they want to communicate to other applications, for example from one process controller to another. So they need an Ethernet to talk to any device anywhere.

The NAMUR Open Architecture is one example as to what IIoT can look like in a process plant.

The main concept of NAMUR is to enable uni-directional, read-only access to field instruments. Both, old and new. NAMUR ideas expand production with central and plant-specific work packages . NAMUR thus defined the data diode – a one-way street for communication.

There are multiple other initiatives such as the Open Process Automation™ Forum lead by Exxon Mobile, OPC UA.. etc.

A sophisticated protocol such as OPC UA comes in handy for this type of communication.

Ethernet for process automation enables access to instruments in the field of a process plant.

Ethernet-APL is one variant of a single pair Ethernet. Additional specifications apply to achieve fitness for the harsh conditions and demands of process industries.

Users of Ethernet / APL will be able to make full use of the wealth of information that field bus devices capture and make available. For example, you can centrally monitor the status of your field devices with condition monitoring and thereby detect maintenance requirements at an early stage. The concept of predictive maintenance has great advantages, particularly in the process industry, because you can avoid the need to temporarily shut down plants. The greatest benefit, however, is when data can be used to monitor and optimize the condition of the entire plant.

The Ethernet APL Technical Specification is as follows...

Parameter	Specification
Standards	IEEE 802.3 (10BASE-T1L), IEC TS 60079-47 ED1 (2WISE)
Power supply output (Ethernet APL power switch)	Up to 60 W
Switched network	Yes
Reference cable type	IEC 61158-2, Type A
Maximum trunk length	1000 m / into Zone 1 / Div. 2
Maximum spur length	200 m / into Zone 0 / Div. 1
Speed	10 Mbps, full-duplex
Hazardous area protection: Inspired by fieldbus	For all zones and divisions. With optional intrinsic safety at the device

10 Mbps of data speed and 60 W power. Four times more than with fieldbus today. Trunk cable distance of 1000M and 200M cable distance at each spur. Ignition protection for any hazardous area – just the same way we do it today.
Intrinsic safety is an integral part of APL. It is definitely inspired by fieldbus, meaning extra easy handling in practice.

- Simple documentation procedures.
- No calculations.
- The validation process will be just as simple as users rightfully expect it to be.

Figure 1 shows the infrastructure today we use..

The DCS system / PLC controls access to the field.

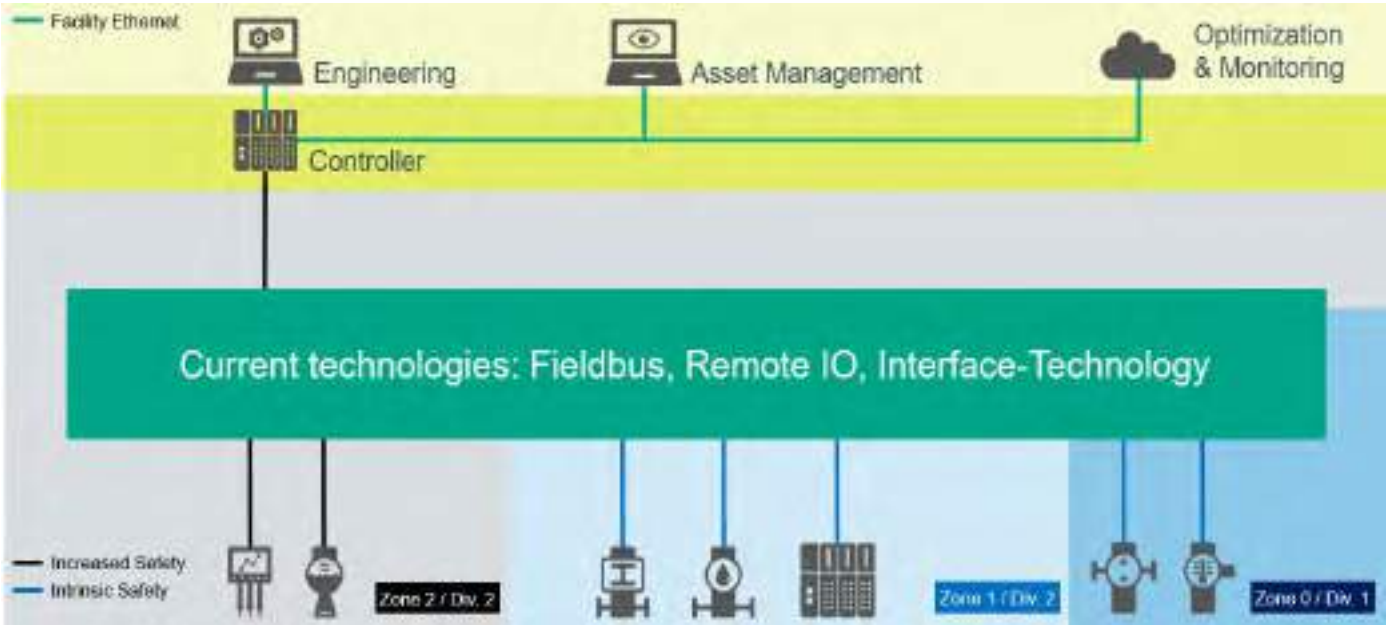

Figure 1

Ethernet in the field is represented in Figure 2

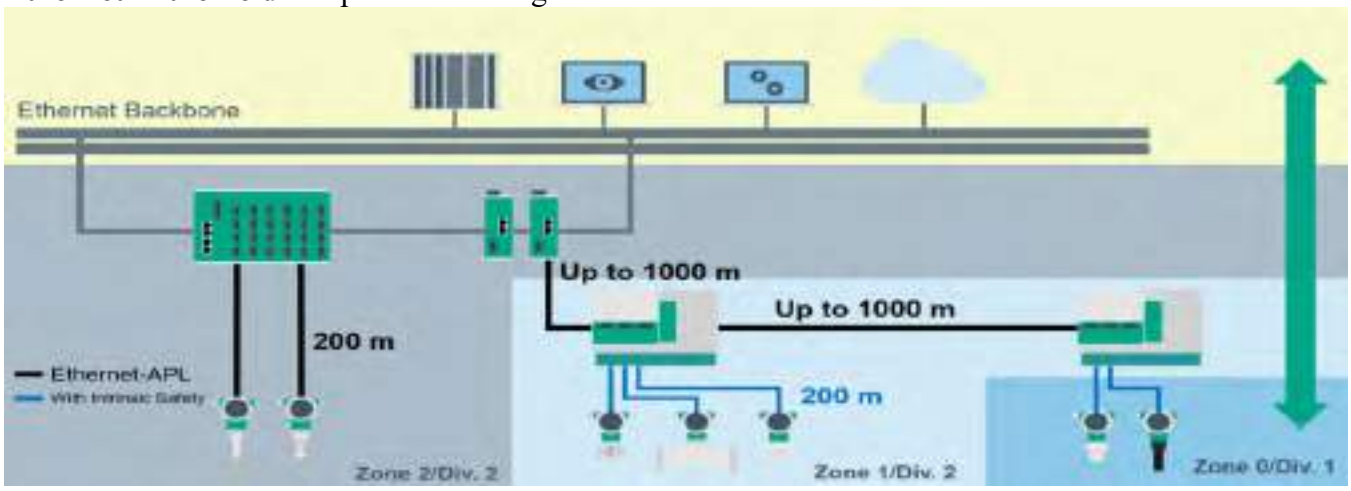

Figure 2

Communications to the field is independent of the controller or the DCS.

Field Switches provide connectivity in hazardous areas, which is Installed in Zone 1 / Div. 2 inside the junction box.

The topology remains the same as with fieldbus.

And of course the same rules for validation of intrinsic safety apply.Access to all assets becomes easier because of transparent and barrier free communication.

APL Power and Field Switches by Pepperl+Fuchs provide the reliability for the communications infrastructure

This is why all companies of the APL Project work together.

There must not be another fieldbus war.

APL / Ethernet to the field is organized by the three major standards organizations involved in process automation. (Figure 3)

Figure 3

The APL Project is supported by several key suppliers (as given in Figure 4) in process automation.

Figure 4

They all strive for a common goal: A single physical layer that can carry any protocol.

SUMMARY

As we discussed earlier: Ethernet APL is "just" a new physical layer for Ethernet and any higher layer as defined in the ISO/OSI model does not need any knowledge about it. There are virtually no limits.

Ethernet APL enables Ethernet communication. Ethernet APL is a foundational technology that enables broad and innovative product development. From engineering companies to plant and skidbuilders, from service providers and data vendors to end users, everybody will benefit from the digitization of process plants.With its ability to combine Ethernet communication with power over one and the same twisted-pair wiring, the new and easy-to-handle physical layer will trigger a completely new generation of devices and infrastructure components that will simplify process technology and enable completely new applications in process automation.

ACRONYMS

CPS - Cyber Physical System
APL - Advanced Physical Layer
IP - Internet Protocol
IOT - Internet of Things
IIoT - Industrial Internet of Things
OPC UA - Open Platform Communications Unified Architecture
DCS - Distributed Control System
PLC - Programmable Logic Controller
NAMUR - Normenarbeitsgemeinschaft für Mess- und Regeltechnik
FF - Foundation Fieldbus

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Significance Of 5G On Industrial Automation In The Era Of Industry 4.0 And Beyond

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INTRODUCTION

5G is the 5th generation Cellular Network whose deployment began worldwide in 2019. It is the latest global wireless Standard after the era of 1G ~ 4G as per as the commercial deployment is concerned. It is noteworthy that- when we discuss about 5G, there are already as many as five countries & blocks leading the charge of the 6G Mobile network and 6G is also expected to be launched in 2029.

Presently 5G networks are in use in at least 21 countries in the world and counting. All major Android phone manufacturers are in the race for commercialisation of 5G phone. However, apart from personnel mobile communication, 5G has much more to offer, as the advent of 5G is more than just a generational step; it opens a new world of possibilities for every tech industry. Our discussion here is "the role of 5G technology which has significant impact on Industrial Automation in the present era of Industry 4.0".

The evolving 5G networks are becoming a significant driver of the growth of IoT and other intelligent automation applications. 3GPP, which is one of the standards for 5G, has identified a set of performance targets for Industrial automation using 5G. 5G technology is becoming the key enabler of the requirement set by this standard. Lightning-fast connection and low-latency of 5G are boons for advances and development in intelligent automation—the Internet of Things (IoT), Artificial Intelligence (AI), driverless cars, digital reality, Blockchain, and future breakthroughs. The purpose of this paper is to explore how 5G can enable, streamline and augment intelligent automation. This paper also discusses the evolution and development of various generations of mobile wireless technology, underscores the importance of 5G revolutionary networks, and reviews its key enabling technologies.

KEY WORDS

IoT, 5G, Industrial Automation, Ultralow latency, Industry 4.0

THE PROMISE OF 5G TECHNOLOGY

The mantra of 5G technology is “A design to connect everyone and everything”. It is a huge promise which includes a network design having Ultralow cost, Ultralow energy, Deep coverage, Ultrahigh capacity, Robust mobility, Ultrahigh reliability, Ultralow latency, High security and Extreme broadband capacity. The demonstrated peak data speed is 20Gbps and the fastest 5G network is known as mmWave.

The International Telecommunication Union (ITU) has classified 5G mobile network services into three categories: Enhanced Mobile Broadband (eMBB), Ultra-reliable and Low-latency Communications (uRLLC), and Massive Machine Type Communications (mMTC).

THE EVOLUTION OF MOBILE NETWORKS

For the last two decades mobile networks have evolved from 1G to the present generation.

THE FIRST GENERATION - 1G was deployed in 1980 with analog voice transmission. It was meant for talk only service and be mobile. There was no data transfer capability amongst the devices in 1G network.

SECOND GENERATION - 2G has come in the early 1990s**. 2G** introduced digital voice (e.g., CDMA- Code Division Multiple Access). SMS and with roaming services were provided with data transfer up to 40kbps. Nokia 3310 was one such mobile which we all loved so much.

THE THIRD GENERATION - 3G got deployed in the early 2000s. With a digital data transfer rate up to 21 Mbps, the biggest change therefore was the mobile data speed mobile data (e.g. CDMA2000). GPRS was another gift of this technology. On board data storage with limited capacity became possible.

THE FOURTH GENERATION - 4G is one of the most widely penetrated mobile networks across the globe which started in 2010s as 4G LTE (Long Term Evolution). Broad band has become a household phenomenon with data speed up to 1 Gbps. All the IP services like Voice & Data-high quality audio video data, unified networks & protocols became possible.

THE TECHNOLOGY BEHIND 5G

The 5G networking technology standard is divided into two key parts: Non-Standalone (NSA) and Standalone (SA). The first 5G networks are based on NSA, which is the basis of initial commercial launches. The NSA standard uses existing 4G LTE infrastructure to handle the Control Plane and the signal traffic. The SA comes with entirely new core architecture. It moved the control plane transition over to the 5G Core and made significant changes for the way that networks operate. SA is more recent and it supports more flexible network slicing and subcarrier encoding.

The 5G New Radio (NR) standard uses OFDM (Orthogonal frequency-division multiplexing) on both the uplink and downlink.

OFDM is an efficient modulation format used in modern wireless communication systems including 5G. OFDM combines the benefits of Quadrature Amplitude Modulation (QAM) and Frequency Division Multiplexing (FDM) to produce a high-data-rate communication system.

Fourth-generation (4G) Long-Term Evolution (LTE) wireless technology requires high-power, large cell towers to radiate signals over long distances. 5G wireless signals, *on the other hand, are transmitted via large numbers of multiple small cell stations located in places like light poles or building roofs*. The use of a large number of small cells is necessary since 5G relies on millimeter wave spectrum mmWave between 17 and 110 GHz which can only travel over short distances and is subject to interference from weather and physical obstacles.

New technological innovations in 5G like mmWave, Sub-6 GHz, beamforming and massive MIMO (Multiple Input Multiple Output) are briefly discussed below.

mmWave: It offers a very high frequency between 17 and 110 GHz and high bandwidth for fast data transfer. It is a short-range technology that will be used in densely populated areas.

Sub-6 GHz: Most of the future 5G networks would operate in WiFi-like mid-band frequencies between 3 and 6 GHz. It covers the medium range spectrum, and is useful for small cell hubs for indoor use or more powerful outdoor base stations.

Beamforming: This key technology allows the beamformer (Router) to transmit signals in the direction of the consumer devices, thus creating stronger, faster, and more reliable wireless communications. Beamforming is a key technology in overcoming the range and direction limitations of the spectrum of high-frequency waveforms.

Massive MIMO: Data is sent and received using multiple antennas on base stations to serve multiple end-users. The technology makes high-frequency networks much more efficient.

KEY FEATURES OF 5G AND HOW IT IS DIFFERENT THAN 4G

EDGES OF 5G OVER 4G: 5G networks provide lower prices, lower battery consumption, and lower latency than 4G wireless networks. It is because 5G uses Ultra-Wide Band (UWB) networks with higher band breadth at low energy levels. It is five hundred times faster than 4G wireless networks. 5G communication networks can also provide hundreds of billions of connections, massive machine communication, and extreme mobile broadband. Additionally, 5G offers ultra-low latency of 1 ms, 90% more energy efficiency, 99.9% ultra-reliability, 20 Gbps peak data rate transmission speeds, and mobile data volume of 10 Tb.

A UNIFIED PLATFORM THAT IS MORE CAPABLE: supports all spectrum types (licensed, shared, unlicensed), bands (low, mid, high), all range of deployment models (from traditional macro-cells to hotspots), new ways to interconnect (such as device-to-device and multi-hop mesh). Supports mission-critical communications & the massive IoT.

BETTER USE OF SPECTRUM: most out of every bit of spectrum from low bands below 1 GHz, to mid bands from 1 GHz to 6 GHz, to high bands known as millimeter wave 5G network is super efficient.

STANDARD BEING FOLLOWED IN 5G

5G is an evolving technology. Below are the primary international standards which broadly covers this technology.

(a) International Telecommunication Union's IMT-2020, (b) 3GPP 5G NR (New Radio) standard with LTE (c) 3GPP 5G specifications: I-Phase 2019, II-Phase 2020 and (d) The IEEE 1914.1 standards for network architecture.

BEST SUITED USES OF 5G

5G opens up a whole world of opportunities across all tech industries. The following three categories define the best suited use cases with it's three cornerstones - increased speed, decreased latency and increased connectivity.

- **Enhanced mobile broadband:** as it provides better smartphones, faster VR and AR, more uniform data rates, lower latency, and lower cost-per-bit and Xtreme Reality.

- **Mission-critical communications:** it can transform industries with ultra-reliable, available, low-latency links like remote control of critical infrastructure, vehicles, medical procedures and critical industrial automation.

- **Massive IoT:** It seamlessly connects a massive number of embedded sensors in virtually everything providing extremely lean and low-cost connectivity solutions.

5G AND GLOBAL ECONOMY

As a global growth driver, it has already delivered-$13.2 trillion dollars of global economic output, 22.3 million new jobs created, set for $2.1 Trillion dollars in GDP growth by 2035 that goes up to $13.2 trillion worth of goods and services, thereby 5G is fast becoming a boon to Industry 4.0 and for the forthcoming Industry 5.0.

SECURITY CONCERN

- 18-10-2018, a team of researchers from ETH Zurich, the University of Lorraine and the University of Dundee released a paper entitled, "A Formal Analysis of 5G Authentication". It alerted that 5G technology could open ground for a new era of security threats. The paper described the technology as "immature and insufficiently tested," the one that "enables the movement and access of vastly higher quantities of data, and thus broadens attack surfaces".

- Network security companies such as Fortinet, Arbor Networks, A10 Networks, and Voxility advised on personalized and mixed security deployments against massive DDoS attacks foreseen after 5G deployment.

- IoT Analytics estimated an increase in the number of IoT devices, enabled by 5G technology, from 7 billion in 2018 to 21.5 billion by 2025. This can raise the attack surface for these devices to a substantial scale, and the capacity for DDoS attacks, crypto jacking, and other cyber attacks could boost proportionally.

Therefore, providing a reliable cooperation among heterogeneous devices is vitally important for 5G mobile networks. In this regard, Blockchain with its immutable and decentralized transaction ledgers can enable distributed massive communication with high security and trustworthiness. Due to the advanced technical capabilities to support future network services, Blockchain is regarded as one of the key technical drivers for 5G at the 2018 Mobile World Congress (MWC).

WHO ARE THE MAJOR PLAYERS?

Huawei (China), Ericsson (Sweden), Qualcomm (US), Verizon (US), Orange (France), Mobile Tele Systems (Russia), AT&T(US), Samsung (South Korea), Nokia Networks (Finland), ZTE (China), NEC (Japan), CISCO (US), CommScope (US), Comba Telecom Systems (Hong Kong), Alpha Networks (Taiwan), Siklu Communication (Israel), Mavenir (US). Reliance Jio has also been conducting trials for its 5G network. It's first 5G trial run was done in Gurugram's Cyber Hub.

5G AND IOT

A general IoT basic architecture comprises of four basic layers (a) Wireless sensors actuators, and network layer (b) Internet Getaways and Data Acquisition Systems (c) Edge IT-Management Services and (d) Data center and cloud.

One of the important elements of Industry 4.0 is IoT. 5G network can improve processes in different layers of IoT architecture. Today's network technologies are not sufficiently equipped for the ultra-connectivity needed for the future. We often need to use a mix of fixed and wireless network technologies to realize massive IoT projects. 5G has the potential to bring the reliability, latency, scalability, mobility, and security that is required for mission-critical services in the IoT ecosystem.

5G AND AUTOMATION

As mentioned above, 3GPP which is one of the standards for 5G, has identified a set of performance targets for Industrial automation using 5G. According to this for application like Motion control, Mobile robotics and Mobile control panels having safety functions shall have more than six-nines (>99.9999%) availability, while cycle time is defined 1 – 2 ms for Motion control, 1 ms for Mobile robotics for cooperative motion control and mobile control panels having safety functions through robots -4-8 ms. Cycle time for Process automation for monitoring is defined as >90 ms with four-nines availability. The cycle time in sub sec ranges means the latency for the subsystems need to be in the order of millisecond to sub milliseconds to cover up the cycle time. A ms cycle for example, may only allow 500 micro second for transmission. 5G is designed to meet this dual demand of ultra reliability and low latency communication (URLLC) requirement (Ref the IMT-2020 standard spec for 5G).

Industrial automation requires local-area networks, deployed on the factory premises to meet URLLC performance targets. The 5G system architecture is designed to fit in to this requirement, with specifications that enable operation on a standalone basis, without dependency on external networks. Typical private 5G wireless networks comprise Radio

Networks and Core network element. In case of 5G, the core network is deployed on edge compute nodes installed on –premise- i.e., within the factory environment. Deployment of edge computing nodes for 5G Industrial application has a number of potential benefits such as it can be used to offload processing from sensors, enabling simpler designs, longer battery life and lower cost, WAN independent enterprise and data localisation (means data does not have to leave the premise).

CONCLUSION

Mobile communication technology has seen massive technological development starting from its 1st generation to the present 5th generation networks. Increased speed, decreased latency and increased connectivity- which are the basic and most significant benefits of 5G are natural fit case for development of IoT in Industry 4.0 and 4.0+. 5G is designed to meet the dual demand of ultra- reliability and low latency communication (URLLC) requirement as set in the IMT-2020 standard spec for 5Gfor industrial automation. As the cyber security always remains a concern, one of the he international bodies such as Mobile World Congress has already identified the blockchain technology as the key enabler to address this concern in 5G. Looking at its promises and benefits, the deployment of 5G therefore is expected to revolutionise industrial automation and particularly in the era of Industry 4.0.

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Operational Excellence at Numaligarh Refinery Limited by Implementing Web-Based, Database-Driven Digital Logbook and Shift-Handover

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The concept of operational excellence is applied to improve the production, safety, quality, and cost performance of industries. This concept is implemented by Numaligarh Refinery (NRL) and they attained the expected quality by implementing web-based, database driven solution for operations management. Earlier at NRL like other Industries, operator logbook was maintained on paper-based form and spreadsheets. Also, they were on siloed & scattered databases and historian data was not shared between the logbook or shift-handover logbook. This inadequate data collection adds an unnecessary risk to operator's safety. To make safer and more efficient way of working for operators, industries adopt digital way and provide operator better communication, consistency, and control. However, lack of integration between various applications i.e., disconnected applications, enterprise inconsistencies lead to unexpected problems, such as, missing out on crucial overlapping of data as operations and HSE personnel using different applications. In addition to interoperability, there is zero mobility which means field operator don't have access to right information at the right time.

This paper describes roadmap of NRL towards a digital transformation in operation management by implementation of web-based, database driven digital logbook and shift handover. The process and the key elements included in implementation of Hexagon j5 Operational Management Software (OMS) solution are explained with its benefits. These digital logbooks provide immediate benefits to operations personnel and other departments, such as maintenance and safety. Therefore, an electronic logbook (E-logbook) or Digital logbook shall definitely grow into a powerful communications tool across multiple disciplines and sites.

KEYWORDS

Operation Management Software (OMS), Digital logbook, Mobility, Web-based, Database driven

INTRODUCTION

In recent past, digital transformation has gained its due importance in every aspect of manufacturing / production Industry. It is not only required for automation in process but also required for mobility in the process to eliminate complete paper and/or excel work in order to achieve the operational excellence. So far, paper, spreadsheets, word processor documents and scattered databases are being used by industries commonly. These inadequate and scattered data / information is being used for critical operator procedures like shift-in charge logbook and shift handover. This in turn, add risk to operator or worker safety.

Numaligarh Refinery Limited (NRL) presently operates a 3 MMTPA refinery in Golaghat District in the state of Assam, India. NRL produces motor spirit (MS) and high-speed diesel (HSD) primarily conforming to BS-IV specifications by processing Assam Mix Crude. In 2019, Govt. of India has approved capacity expansion of NRL from current 3 MMTPA to 9 MMTPA by installing new 6MMTPA refinery unit at its existing location in Assam. During this expansion phase, NRL has decided to take step towards digital transformation in operations management solution. This paper elaborates how conventional paper logbook and shift handover logbook is transformed into digital form using Hexagon j5 operations management solution. j5 OMS solution benefits with web-based, database driven digital logbook and shift handover. These digital logbooks help in operations, maintenance, and safety personnel with safer and efficient way of working.

CONVENTIONAL PAPER LOGBOOK

With the constant advancement of IT technology over the decades, paper logbooks are becoming increasingly obsolete. The major reasons of drawbacks of conventional paper logbook are listed below:

1. KEY INFORMATION MAY BE DIFFICULT TO FIND

For field or console operational personnel, it is very important that correct real-time information is readily available. Paper logbooks are usually filed away in folders, or in cabinets and archives, makes the process of finding specific information a tedious task. For example, searching for key operations information can be like finding a needle in a haystack.

2. ILLEGIBLE HANDWRITING

Everyone has a different style of handwriting and sometimes it can only be recognised by the person who wrote it. Therefore, the information or critical message from one operator to next shift operator is being missed due to such untidy writing. Paper logbooks also encourages short handwriting. Finally, inconsistencies become the norm, and illegible information is as useful as no information.

3. INCONSISTENT LOGGING AND REPORTING

A thesaurus proves that there are often many names for the same thing. With paper logbooks there is no pre-defined entry structure, which can cause confusion. Inconsistent data entry leads to inefficient reporting with paper logs.

4. POOR WEATHER RESISTANCE

Industrial sites are often situated in extreme environments such as wind and heavy rain. As a result, it is extremely frustrating to write on a piece of paper that is flapping about in the wind or covered in rain droplets. Bad weather conditions can quickly make information illegible.

5. NO WORKFLOW CAPABILITIES

When any incident/ event is recorded on a paper logbook, the information tracking often ends there, unless the logger verbally speaks to colleagues or shows them the actual record they wrote. Follow-up actions are missed with paper logbooks, leading to potential hazards or accidents.

6. NO STANDARD OPERATING PROCEDURES

When information is recorded on a paper logbook, there is no indication of what the logger should do next. So, it leads to missing on corrective actions across the operations teams.

7. ZERO INTERFACING WITH PLANT IT SYSTEMS

Paper logbooks have no interfaces with other plant IT systems, such as Data Historians, the CMMS and many more. This means that error-prone personnel must manually record data from other IT systems.

8. HIGH PRINTING AND STORAGE COSTS

Daily paper logbooks mount up quickly over the months and years. This leads to high paper, printing, and storage costs, especially because they must be kept for regulatory and compliance reasons. This demands the preserving the record for about 5 years which results in additional storage space.

Few sample paper logbooks are shown in Figure 1. It depicts the manual entry by operator for critical parameters and as well the writeup for the observation from the operator rounds.

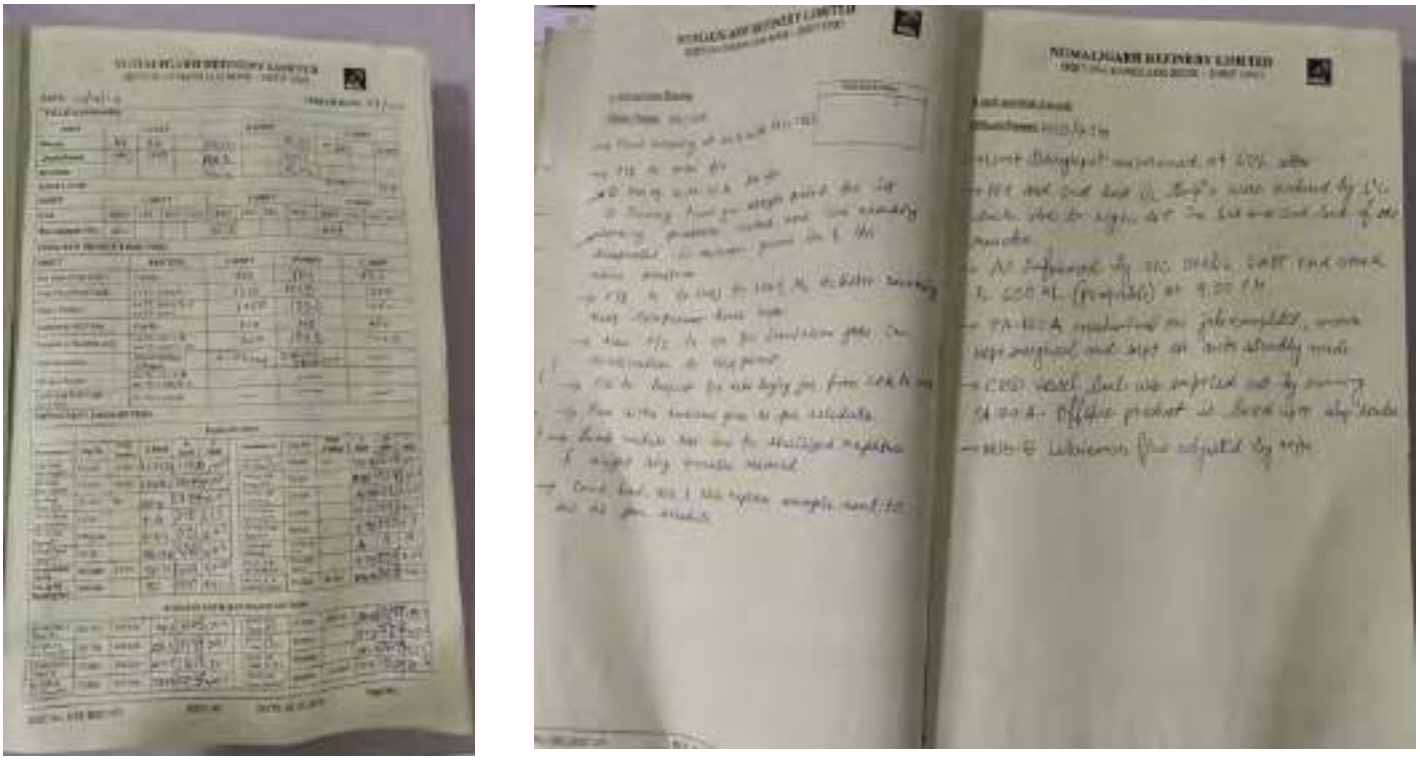

Figure 1. NRL Shift In-charge logbook: sample

With all the above drawbacks, it is advisable to move from paper logbook to electronic or digital logbook for NRL.

IMPLEMENTATION OF DIGITAL OPERATIONS MANAGEMENT SOLUTION AT NRL

NRL has opted Hexagon's j5 Operations Management Software (OMS) solutions with functionalities of j5 Operations Logbook, j5 Shift Handover, j5 Standing Orders, j5 Work Instructions, j5 Event Manager, and j5 Operator Rounds. With a data-centric approach of j5 and no proprietary database, NRL has achieved an integrated environment with a state-of-the-art solution. The j5 OMS solution is integrated with mobile and desktop and all modules running from a single application server and database. j5 has also enabled NRL an integration with IP.21 historian and has ability to read real-time and historical data.

The strategy defined for the implementation of j5 at NRL is as follows:

- NRL has captured the observed and non-automated data within the control room and throughout the plant in different units such as Diesel Hydro-treater Unit (DHDT), Hydrocracker Unit (HCU), Solvent De-oiling Unit (SDU)
- NRL to eliminate paper logbook entries with Digital shift handover system including Operator Logbook, Work Instructions and Standing Orders
- NRL defined workflow mechanism and digital approval from desktop and mobile
- NRL is using historian AspenTech IP.21 and planned integration of IP.21 along with event detection with j5 OMS
- Field mobility by providing tablets to operators for operator field level data entry and checklist, log sheet fill-up
- j5 Mobility also allowed operators to Record audio, video, and take pictures

NRL has implemented this for Diesel Hydro-treater Unit (DHDT), HCU, SDU, Marketing Terminal – NRMT, Power & Utility units. They included 284 numbers of QR code for capturing the tags. NRL has configured approximately 78 logbooks and checklists for these units.

j5 Operations Management Software (OMS) allowed NRL users to create and modify j5 IndustraForm® Templates quickly. j5 IndustraForm® is a patented technology of Hexagon. It has spreadsheet like configuration. This technology supported NRL team for defining the workflow, versioning, and auditability. Using j5 IndustraForm® Templates, NRL operations personnel could take through a step-by-step checklist of plant procedures. These procedures are divided into sections, which follow the approval procedure e.g. approved by managers and / or supervisors when necessary. This has increased awareness between the NRL management and corrective actions are taken without any delay.

With j5 Operator Rounds, NRL team able to share information, assign tasks, and send alerts in real-time.

Figure 2. represents the proposed architecture of NRL OMS with j5.

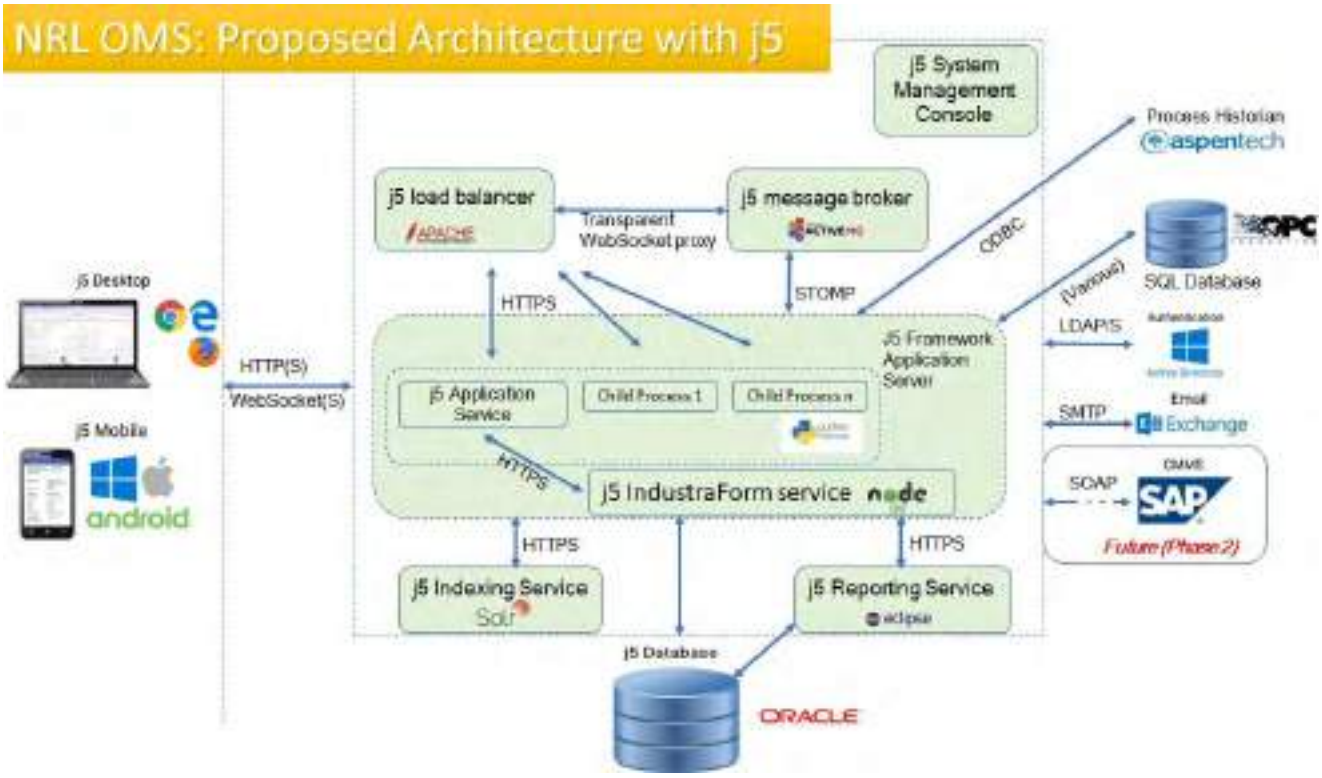

Figure 2. NRL OMS proposed architecture with j5

Sample digital logbook from j5 application with web-based views of operator logbook, shift (handover) logbook and approval section of logbook are shown in figure 4, figure 5 and figure 6 respectively

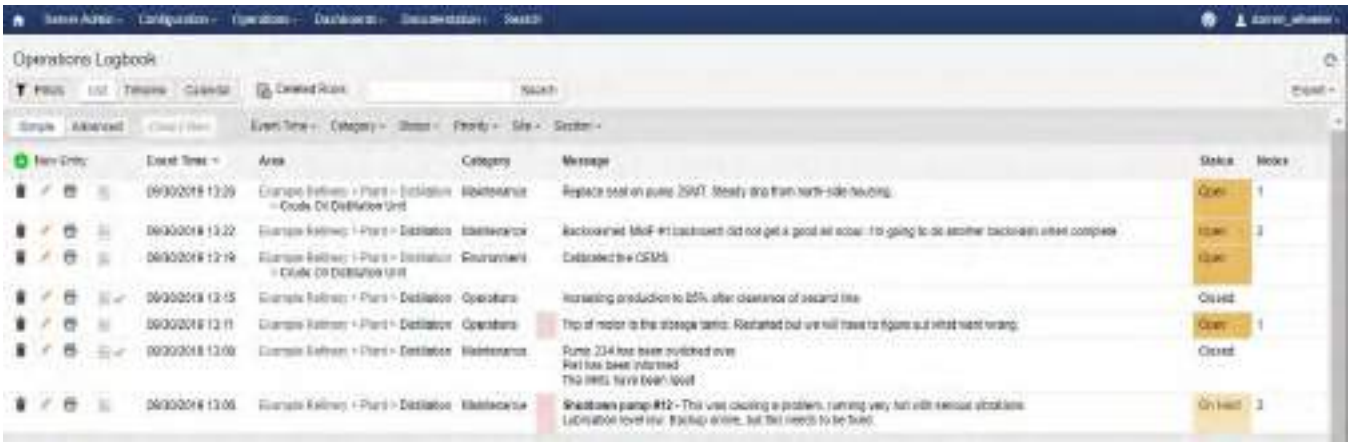

Figure 4. Digital logbook – j5 Operators Logbook (desktop web-based view)

Figure 5. Digital Shift logbook (j5) with important parameters captured by integration with IP.21

Figure 6. Digital approval section of j5 Shift Logbook

NRL operation personnel team is using j5 Work Instruction application on j5 Mobile for the execution of operational tasks in the field (Figure 7).

Figure 7. j5 Mobile application screen and Work Instructions

CONCLUSION

With the implementation of digital system - Hexagon j5 OMS Solution, NRL has taken a step towards operational excellence. NRL got benefited with the following.

- Increased Data Distribution (retrieving of data) - Using j5 Operations Logbook at NRL, information is no longer confined to the control room; rather it is made available directly to all concerned personnel in the refinery. Information is also available to other departments and not to just restrict to operations department. As a result, a better personnel coordination is seen as immediate effect at NRL. Feature of multi-user entry allows more personnel to contribute to the information recording process even through mobile / tablets.
- Formalized Shift Handover - At NRL, j5 Shift Handover provided an efficient, repeatable, auditable shift handover procedure for multiple units. The underlying logic ensures that NRL users follow defined procedures. NRL also benefited with the data which is always online and can be queried at any stage.

NRL finds the significant improvement in shift handover process with the above said key features ofj5. NRL expanded with the following unique features of the j5 operations Logbook.

Real-time Information Integration - Digital logbooks interfaces with IP.21 historian.

Enforces Workflow Practices – The j5 Operations Logbook – defines users' rights to view, create and modify logs and to complete tasks. It includes signing off at the end of the shift, creating and completing work instructions and many other daily processes. It allows intelligent workflows which help operators to not make mistakes.

Data Searching Capabilities – j5 allows to quickly find information. This saves an enormous amount of time compared to older data recording methods such as using paper or spreadsheets.

Advanced Reporting Tools - With j5 digital platform, extensive data reports can be created very quickly. These reports are available online, can be emailed to selectable recipients – on a condition or at a defined periodicity – and can have selectable input values.

EVOLVING ROBUST ENTERPRISE LEVEL IN SAFETY INSTRUMENTED SYSTEM USING IIOT

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Abstract

This article provides detail on Software reliability phase implemented in Safety system and also recommends Operation and Maintenance team to maintain Safety Instrumented System used in existing plant to be updated with latest Software version in-line with requirements as stated in International Standard and Codes of practise. In this paper, it also highlights current practise of maintaining Safety Instrumented System in existing plants and also recommends operation team to rely on digital technology - IIOT thereby enhancing operational benefits of O&M team and creating Safety sustainable environment.

Keywords

Functional Safety, Safety Instrumented System, Operation and Maintenance team, Systematic reliability, Software, IIOT, HMI.

INTRODUCTION

In Operating most industrial processes, especially those in the oil and gas industry, involves an inherent risk due to the presence of dangerous / flammable substances. Therefore, using Safety Instrumented Systems (SIS) is mandatory for executing safety functions that are independent from the process control system and process operator, to address events resulting from loss of process control. Unlike Process control system, Safety Instrumented System are dormant and require extensive diagnostics in order to increase plant availability and reducing number of spurious trips. Data(*6) suggests that Software operational life cycle in Safety Instrumented system are growing less reliable as they advance towards end of life expectancy and most operating companies are not upgrading Safety Instrumented system not due to capital cost but rather opportunity cost of shutting down the pant. This paper presents the approach of having existing Safety Instrumented System to be enhanced with latest available technological updates without shutting down the plant in order to maximize uptime and savings in opportunity cost for the operator that would have incurred based on extended downtime period plus subsequent shutdown and start up period with its own uncertainty. This paper provides in-depth analysis on relying in digital IIOT technology for Safety Instrumented System to enhance operational benefits of O&M Team and to provide sustainable safer operation of plant.

FUNCTIONAL SAFETY LIFE

Each stage of Functional Safety life cycle has set of inputs from conceptual process design and ends with SIS decommissioning outputs and at the end of each phase a verification process shall be performed to confirm the required outputs are planned as indicated in below figure.

Fig. 1. Source: ISA – Functional Safety blog

To achieve functional safety, all life cycle phases need to be addressed, so that failures by life cycle phase can be determined and corrective action can be taken. Main strategy to achieve Functional safety depends on Functional Safety Management, Technical requirements and competence of personnel involved in all above phases such as Specification, Installation & commissioning, Design & Implementation, Operation & maintenance and changes after commissioning.

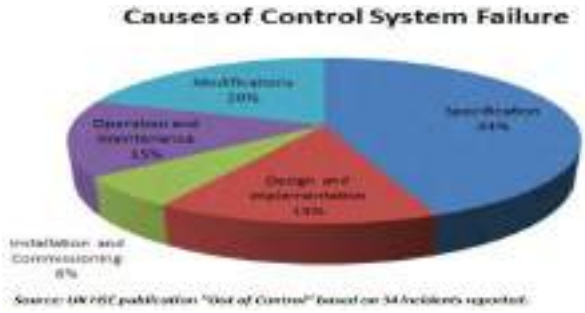


Fig. 2 Source: UK HSE publication "Out of control"

As per above chart, 35% percent of failures are attributable to Operation and Maintenance phase and Modification stage (after commissioning stage), indicating the importance of this part of the life cycle and ensuring compliance with Functional safety standards throughout the life of plant, long after initial project has been completed.

OPERATIONAL PHASE

The third phase is the Operation phase which covers the start-up, operation, maintenance and eventual de-commissioning of SIS. The operation phase is the longest of the Functional Safety life cycle phase as it begins at start-up and continues until SIS is decommissioned or redeployed – Entire working life of the safety system. This phase is dominated by the activities of maintaining and function testing the system to ensure that it remains functionally safe. Hence the system's SIL is affected by the number of times it is tested and repaired to full functioning condition. A proper testing and maintenance regime begins with good planning and relies on solid documentation to show that the plan is followed. Effective management of change is also important so any potential

modifications to the system can be addressed properly. Depending on the exact nature of the modification, such change management should include a full return to the concept phase if circumstances warrant.

CURRENT PRACTISE

With current practise when it comes to legacy of safety system, the adage of "if it isn't broke, don't fix it" is making many operating company's business at unnecessary risk. In today's period of tight budgets and limited resources, it is difficult to obtain the funding to upgrade legacy of safety system especially if that system is perceived to still be working without any problem. In this case, timing is everything.

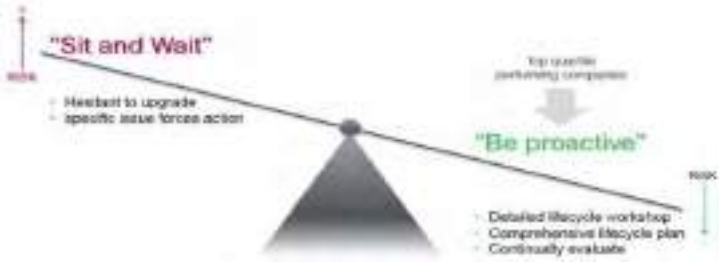
- Reliability
- Total cost of ownership
- System performance
- Availability of spares
- Staff experience and expertise
- Access to the equipment
- Production needs
- Downtime
- Prioritization with other projects
- Company directives
- Standards compliance
- Cybersecurity
- Support costs

Upgrading is not an exact science but whenever an element is out of balance, it can signal that it is time to evaluate if an upgrade is necessary.

HEURISTIC APPROACH

A good practice is to continually evaluate the long-term reliability of the safety systems used in operating plants. It's highly recommended to develop important judgment to upgrade safety system based on the complete understanding of the business impact, ROI, benefits, risks and potential consequences. In simple terms, there are only two choices to make:

1. Sit and wait until incidents arise.
2. Be proactive and develop a plan.



Source Image: SE blog on Modernization of Emergency Shutdown system

As part of current practise, many operating companies seem content to "sit and wait" and are hesitant to upgrade until a specific issue forces them to act, by which time it may be too late. However as good approach, generally, a top quartile operating companies those are intended to attain a low risk tolerance and strong goals in business continuity, will always try to adopt a proactive approach and don't wait for a failure to occur. They establish the current "as-is" state and undertake detailed lifecycle workshops to determine the actual status and lifecycle of the existing equipment. Such companies will set the target for where (and when) they want to be, identify and determine where the gaps are, and then try to implement a comprehensive plan all-together.

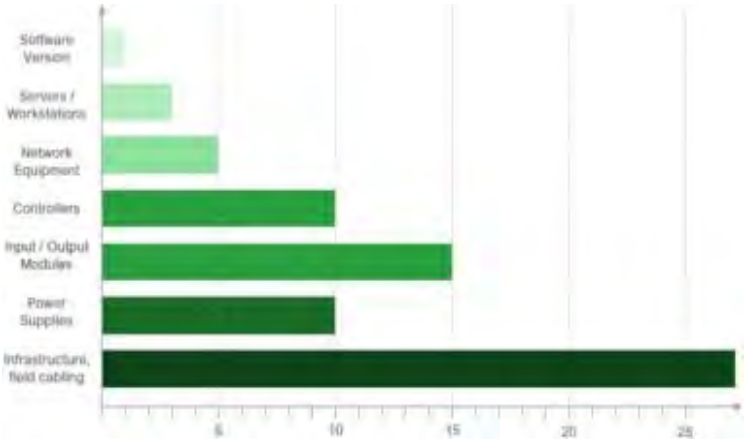
Incase as an alternate solution if replacing an old system with a new one, the system cutover requires careful planning to minimize risk. A comprehensive cutover plan is a critical requirement for seamless transition to a new safety system platform. Without proper preparation, migration projects can be affected by cutover delays and other unexpected issues that may cause downtime.

When planning, there are many factors that should be considered, including:

- The expected operating life of the plant
- Any future plant modifications (e.g. de-bottlenecking) or expansions (adding extra capacity)
- Proactive upgrade planning aligned to turnaround schedules
- Plant availability / access to equipment
- Re-HAZOP cycles
- Re-assessment of Safety Instrumented System verification and validation.
- New requirements e.g. cybersecurity, regulatory requirements, latest standards etc.
- Alignment with existing initiatives or improvement programs (lowers barriers to adoption)
- Maturity indicators and status of existing equipment.

As soon as a plan is developed, it can almost be out of date; such is the pace of technology. Due to the various lifespans of system components, effective lifecycle management is an important process to maintain. When developing the plan, it is worth investigating the lifespan of the various parts of the safety systems as these are likely to be different, with some becoming obsolete faster than others. Not only is it important to upgrade to the latest versions but developed plan also needs to "protect the future" by staying current while also keeping pace with evolving technology.

Every company should have a safety system lifecycle that is reviewed and updated at a regular frequency. This will help to understand the life cycle status and potential risk to be managed, which is essential to optimum time to upgrade. Below image shows a typical example of information depicting the areas of critical control system that requires upgradation in operating plants.



Source Image: SE blog on Modernization of Emergency Shutdown system

PROPOSED SOLUTION

New marketplace demands and especially short production cycles are stimulating the proliferation of Industrial Internet of Things (IIoT) related technologies across industries.

IIoT technology enable data to be quickly gathered and analysed, thereby driving rapid and high accurate decisions. IIoT driven algorithms and predictive analytics can be configured to identify looming threats to equipment safety. IIoT complements risk minimization by improving process safety performance through avoidance of near misses and unexpected outages.

The on-line swing over shall be implemented using a dedicated transitional tool which is having interface with dedicated Human machine interface (HMI). The on-line swing over HMI allows supervision and control of all points regardless of the state of the swing-over i.e. during swing over phase implementation, regardless of whether a portion of the system shall be controlled by existing safety PLC or new Safety PLC system, the HMI will allow control over the transitional from new system to old system and will allow forcing of I/O whether the I/O was in old or new PLC system and during this transition period, Old system shall be enabled with software upgradation facility by interfacing with Vendor's factory enabled cloud based digitization tool using IIoT. The special swing-over HMI will provide operations with complete knowledge of the swing-over status and complete control of any piece of equipment.

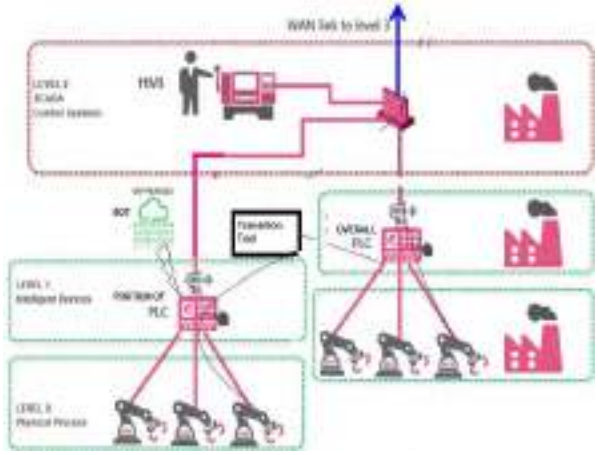


Image: A typical proposed plan block diagram

PROS

Following benefits shall be realized by Operating companies include below,

• Revalidation of the logic and operation of all the equipment in the plant.

• Creation of current documentation including P&IDs, shutdown keys, instrument indexes, drawings, installation details, control narratives, and manuals.

• Operations team can now maintain and manage the new system with confidence, and manage changes using best-practice MOC processes.

• Real and proven technological advancements and processes can enhance profitability, operability and life span of aging of physical plant assets.

CHECKLIST

The proposed method is not traditional, main-stream thinking to try and do it – it is a complex process that demands acute attention to detail, very strong planning and execution skills and a cohesive, dedicated team of Vendor, Operator and Engineering company specialist that are passionate about making it work.

Key to this concept is the involvement of plant operations team. Following points provide action points (as a minimum) that needs to be considered by Operator while performing upgradation activity.

1. Perform a risk assessment of each individual machine and complex system (multiple machines). Use existing records of injuries to determine the cause.

2. Using the results of the risk assessment, determine the level of safety required for each machine and complex system. The level of safety is determined by assessed risk (severity) and probability of injury. The solution will be based on local and national requirements.
3. Work with a qualified, reputable distributor that has a wide product breadth to meet the needs of the safety level.
4. Obtain all of the electrical schematics of each machine, whether on its own or within a complex system. This will allow to determine if and how will integrate the necessary safety devices. Contact the manufacturer of the machines. They may have made upgrades to their offerings that may retrofit into the existing equipment.
5. For complex systems, develop a safety schematic to show how all of the safety devices interact with the system. This should include the "brains," as well as all of the interlocking devices.
6. If there exists don't have a safety-trained electrician in-house, hire an integration company. This will be an additional cost, but they will guarantee their work and could assist with the above steps.
7. Even though this is listed last, it should by no means happen last. Develop the training module. It should include all of the information gathered and developed along the way. It will be specific to needs, and it can add it to training matrix, if training records are followed.
8. With well-trained assistance from Safety Consultants, key maintenance and operations team and vendor will check swinging of one control loop at a time from old system to new system.
9. Co-ordination of Operation team to work with Safety consultants and Vendor swing -over team to create a detailed plant to ensure and confirm that Swing over method is safe and acceptable to all parties.

CONCLUSION:

Introducing such a digital tool – IIOT in upgrading existing critical system software version in safety instrumented system will enhance quality and efficiency by utilizing data transfer to be smart and secured. Safety Instrumented System are adhered to functional safety standards by utilizing "Proven in use" methods and implementing such technique will further enhances Safety Instrument System to have increased Systematic reliability level and thereby evolving operator to rethink on upgradation of processing facilities to maximize uptime in production facilities.

By implementing the proposed solution, production will be well maintained and the operator will have top-tier facility from a safety, reliability and availability perspective. Further operating cash flow will be well safeguarded.

ACRONYMS

SIL Safety Integrity Level
IIOT Industrial Internet Of Things
RRF Risk Reduction Factor
SIF Safety Instrumented Function SRS
Safety Requirement Specification PFD
Probability of Failure in Demand SIS
Safety Instrumented System

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BIOGRAPHIES:

M. Ulaganathan was born in Tamilnadu, India in year 1990. He graduated in Electronics & Instrumentation from Anna University. At present he is working as Instrumentation Engineer involving design, engineering, procurement of I&C for Oil and Gas industry in M/s. Saipem India Projects Private Ltd.

Session – 6

Automation and Pharmaceutical Industry

1. Overview of the Pharmaceutical Industry

The global pharmaceutical industry, which caters to the safety and health of human beings is at cross-roads. This USD 1.2 trillion industry is continuously growing at tremendous rate. On one side there are tremendous opportunities due to increased awareness on health, better paying capacity of the middle class & improved technologies but on the other side there are challenges due to COVID 19, demanding customers and stringent requirements laid down by the regulatory authorities. The Indian pharmaceutical industry is no different. India caters to not only its own 1.3 billion population but also to the whole world. India produces more than 50% global vaccines at competitive prices and is also the largest supplier of generic medicines across the globe which includes highly regulated markets like USA, Europe, Japan, Australia etc. India has the highest number of USFDA approved plants outside USA which results in exports of more than USD 21 Billion.

There are lots of opportunities for the Indian pharmaceutical industry like:

- Growing awareness on healthcare
- Increase in spending power
- Health Insurance schemes
- Penetration of healthcare facilities to remote corners
- Rich availability of educated and trained manpower at comparatively low rates.
- Favorable policies of the government to promote investment

2. Challenges :

Historically, pharmaceutical industry has been risk-averse and moves cautiously. One of the major reason is that pharmaceutical industry has to deal with human safety, regulatory bodies, need to invest highly in R&D and has to carry out painfully long trials before the drug can be commercially launched in the market. This calls for huge investments in R&D before any manufacture or launch can be done. The pharma sector preferred to invest in new plants and new drugs rather than in automation but this picture is now changing. There is a growing awareness on the need of automation, data analysis , computerization etc.

Some of the considerations are as follows:

2.1 Patient safety: Since pharma sector caters to patients / human beings, the safety of the drug and its side effects becomes a primary criteria. Therefore, it is imperative to produce drugs which are safe to use, complies to the requirements and have consistent & reproduceable quality,

2.2 Product Quality: Till a few years ago, pharmaceutical manufacturing was manual (or semi-automatic) in nature and was heavily dependent on operators for operation of plants and recording of data. Due to dependency on operators, there was inconsistency in plant operation and hence quality of product. Over a period of time, a need was felt to improve consistency of quality, improvement in productivity and transparency in documentation which revolutionized the need for automation in pharma sector. Right from simple PLC based systems to DCS, LIMS, EDMS, Empower etc. all type of automations are being used. With improved confidence, pharma sector is ready to embark on its next digitalization journey.

2.3 Regulatory Compliance: The Pharmaceutical industry is heavily controlled by regulatory bodies of the countries where the drugs are sold especially the developed countries. The companies have to comply to the national / international requirements prepared by the regulatory bodies to ensure that the drugs produced are safe for human use and are produced in a cGMP environment. Any major non-compliances to the cGMP guidelines makes a major news in the market and have been found to reflect in the stock market prices.

2.4 Data Integrity and Transparency

During R&D, trials and manufacturing of drugs, a lot of data is generated. This data is needed to prove to the regulatory bodies that the manufacturing complies to the requirements of cGMP and can also be used to find opportunities of cost reduction & increase in productivity. Traditionally, manufacturing in Pharmaceutical sector has been done with manual operations and data has been recorded manually by operators. This often raises doubts in the minds of the regulatory bodies about the authenticity and integrity of the data. On top of that there are issues related to over writing, cuttings etc. In view of this, automation is well preferred where the issues of falsification of data, corrections, over writing etc are taken care of.

Going paperless (Batch Production Reports, maintenance reports, testing records etc) will improve efficiencies and increase speed of execution besides making them mistake-proof. In pharmaceutical sector, there is a specific requirement to store documents for a period of two years more than the expiry date of the drug. E-documentation can help to store the information in a better way with quick retrievability. Cloud Computing can help to store important data in a global network that can be accessed from across the world instead of only the office. This will make the work processes more efficient and agile.

2.5 Speed to Market

As already mentioned, Pharmaceutical product development and trials involve a large amount of data which is required for registration of products before commercial launch. Automation in data generation which ensures complete transparency, authenticity and quick analysis can help in speeding up new product launches. This in turn helps companies to recover their investment in R&D in much less time as compared to earlier. Of course, the patients also get newer drugs in shorter durations.

2.6 Golden Batch / Business analytics:

Pharmaceutical production is carried out in Batches. Due to variations in operations and variations in raw materials, there are variations in quality and productivity of batches where the concept of Advanced Analytics / Golden Batch comes in picture. Advanced Analytics will help to analyse the process parameters of the golden batch and will help repeat them in all the batches so that all batches have best yield and best quality.

2.7 Smart sensors:

Smart sensors can be used in manufacturing, equipment health analysis and in storage & transportation.

One of the important driver for efficiency is OEE of equipment. The equipment can be down due to many reasons like cleaning, mechanical damage, electrical issues, corrosion, wear & tear, reduced performance etc. In some cases, the unplanned equipment downtime can have impact on production or quality of product which can result in huge financial losses or loss of brand image. This calls for 24x7 real-time monitoring of the equipment. **The internet of Things** (IoT) comes into picture and helps in forecasting breakdowns and informing the concerned persons who can take timely action to reduce the impact of the breakdown. Also, in operations / manufacturing area, The IoT helps to transmit real time data to the concerned people, including QA, who can keep a track of the status of the operations.

Smart Sensors along with IOT ensure that the drugs are stored in required environmental conditions in warehouse or during shipping. The temperature / RH fluctuations, vehicle accidents, excess vibrations , delays etc can hurt both patients and pharma companies. For example, the COVID 19 vaccine manufactured by one of a company has to be stored at extremely low temperatures. By use of latest technology, the actual conditions during storage or shipment can be monitored and actions can quickly be taken in case of any problem.

2.8 Supply Chain automation:

Use of Smart Sensors and IoT has already been mentioned above. Warehouse and supply chain automation have multiple benefits as pharmaceutical sector has thousands of SKUs. Automation can bring efficiencies by tracking the movement of finished products as well as raw materials across suppliers, customers and warehouses. The inventory levels can be optimized by the use of forecasting models and advanced Material Resource Planning (MRP).

2.9 Operator Safety :

During operations, hazardous chemicals may also be used. Also, there are drugs which can impact the health of operators. Automation can help in remote operation of the plant so that the operators are safe. At the same time, with automation, there are fewer chances of the drugs getting contaminated with human touch. Use of SIL / SIS / RL classified instruments make the plant safe to operate.

2.10 Remote auditing

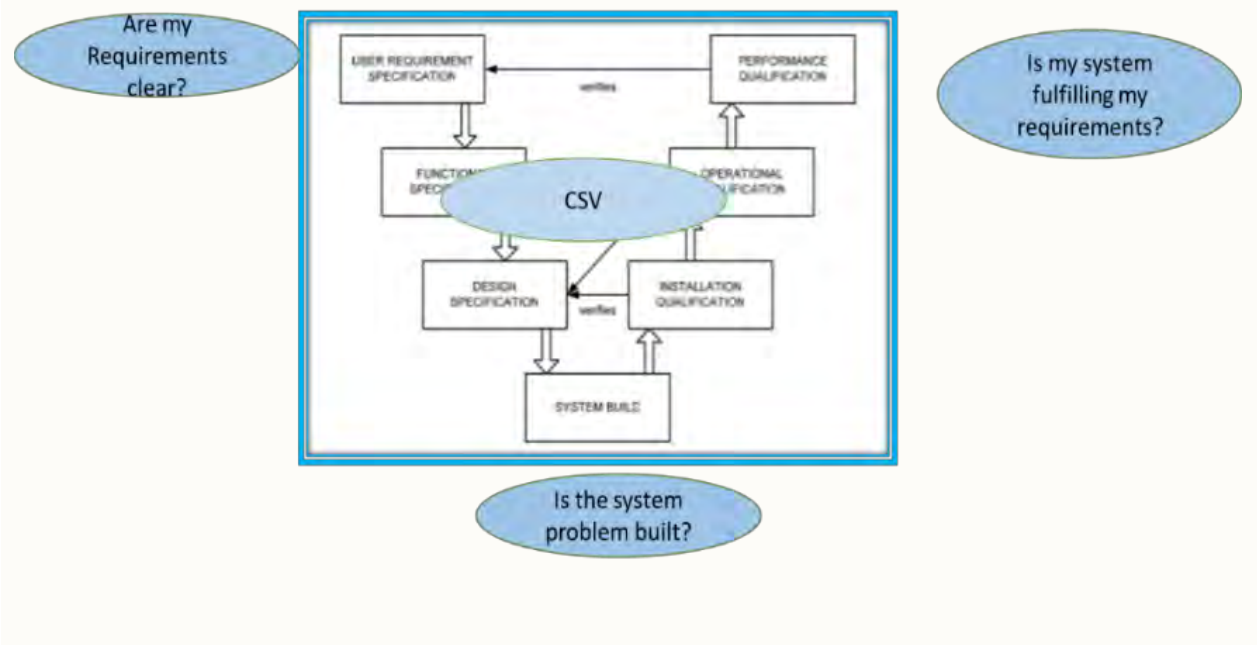
Current interruptions in travel due to COVID 19 has highlighted the need for remote interactions which includes remote audits of sites. Before COVID 19, this situation was unthinkable in pharma sector but the pandemic has compelled the regulators and the industry to change the method of audits. Luckily, some digital tools were available or have been quickly developed which has contributed to its speedy acceptance. Currently, good and user friendly technologies are helping the organisations to remotely audit the vendors, thus saving precious time and money while remaining safe.

2.11 Connectivity with ERP / MES / Remote networks :

The automation does not stop only at the manufacturing sites only. Interconnectivity of the IT and OT systems can help the organization reap the benefits of automation.

3 Automation Guidelines:

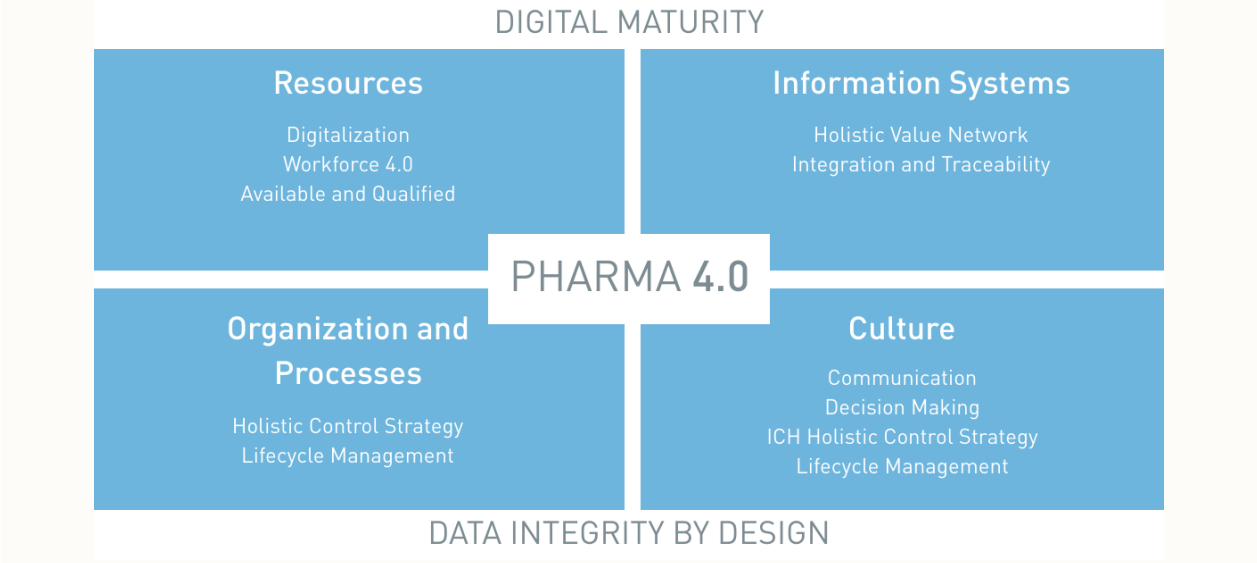
Various regulatory agencies (USFDA, TGA, CDCSO, MHRA etc) of all the countries have their requirements which the organizations have to fulfill. These requirements mainly focus on the cGMP aspects of installation, manufacturing and storage. **ISPE (**The International Society for Pharmaceutical Engineering), a not-for-profit association which serves its Members by leading scientific, technical, and regulatory advancement throughout the entire pharmaceutical lifecycle has issued guidelines for Computer System Validation (CSV). This provides universal guidelines for the project phase, operational phase and retirement phase of the automation systems. An example for validation / qualification of Computers System Validation guidance is given below.



4 Industry 4.0 / Pharma 4.0

Industry 4.0 refers to a new phase in the Industrial Revolution that involves advanced manufacturing techniques, smart sensors, interconnectivity, automation, machine learning, advanced data analytics etc so that the complete operations can be made intelligent and transparent.

ISPE is developing a roadmap to introduce Industry 4.0, also called the Smart Factory, in the pharmaceutical industry as **Pharma 4.0™**. Pharma 4.0™ will usher a new revolution but its implementation will be quite complex. It is also important to develop business cases to showcase which Industry 4.0 automation and digitalization technologies can be applied to pharma while remaining within the complex regulatory challenges.



Pharma 4.0™ will enable faster decision-making by providing real time data on a global platform.

5 Summary

With the modern manufacturing plant of the future, pharmaceutical companies can unlock new levels of efficiency through interconnectivity, advanced data analysis, remote visualization, predictive maintenance, digital twin technology, supply chain management, and process automation. Of course, while unlocking the potential of Digitalisation, security of data and training of man-power will be the next challenge.

Digital transformation and Automation is not just

"Nice to Have".

It is

"It is a Must to Have".

Remote Visualization

Advanced Batch Analytics

Security of data / Authorized Users

Digital Twin

Lab Information Management System

OEE Improvement

Pharmaceutical Plant of the Future

SMART LOGISTICS & INFRASTRUCTURE

V V V Prakash
Bechtel India Pvt Ltd, Gurugram

ABSTRACT

The challenges posed by Industry 4.0 and the increased use of Internet of Things (IoT) and Cyber Physical Systems (CPS) have resulted in innovating "smart solutions" to develop the Logistics and Infrastructure industry with the digital transformation by the use of "smart sensors", "big data", and "analytics". The emerging technologies are facilitating new opportunities like proliferation of IoT devices, which provide sensors and controllers that can be embedded into any physical machine to be controlled and managed remotely and 5G communication technology, which provides high speed communications needed for managing and controlling transportation systems in real time with minimal latency. These technical advancements have enabled Companies and Organizations to improve the efficiency of their supply-chain operations.

KEYWORDS

Smart Logistics, Smart Infrastructure, Smart City, Smart Solutions, ICT, ITS

INTRODUCTION

"Smart Logistics" define the "smart" way of structuring the traffic management and navigating traffic for optimal use of traffic system and efficient logistics management, which includes the efforts of organizing, planning, control and execution by effective usage of "big data". The Smart logistics concept is mainly deployed within the area of inner-city distribution including accessibility and efficient transport within the cities which facilitate healthy human life and better environment. As the Countries are taking serious measures to improve the air quality by reducing CO_2 emissions, Cities are taking a big leap in the sustainability efforts in maintaining cleaner transport within the city boundaries by implementing innovative smart logistics solutions. The need for defining and implementing "smart solutions" for city distribution is increasing every day from both an organizational and technological perspective as the application of smart logistics offer growing business opportunities to

both the logistics Companies and their Clients. To facilitate an effective implementation of the smart solutions, the Cities shall adapt a governance model in which both the Public and Private sectors collaborate in decision making and are equally responsible to establish a healthy cooperation along the entire value chain. The integration of open source data of public and private entities with the exchange of traffic and logistics data will improve the operations of the both the entities. Smart logistics solutions deliver efficient transport & warehousing and enhance the connectivity between different logistics networks, which create new connections between IT specialists and logistics service providers.

SMART INTELLIGENT CITIES

The optimization of logistic processes through digitalization and use of Information Technologies will accomplish the goal of implementing modern concepts of functioning of Smart cities. The Smart "intelligent" cities facilitate easy access to information, developing procedures supporting the effective operation of offices and services. City residents can deal with offices with faster communication, enjoy better functioning of public transport and feel safer, owing to their access to the current information about what's happening in the city. The Smart city intelligent technologies create new possibilities of energy conservation with reduced emissions of CO_2 thereby good control can be achieved on the transportation. The Smart cities connect people, information and city elements using new technologies to create a sustainable, greener city, competitive and innovative commerce, and an increased life quality. The key feature of Smart city is intelligent exchange of information between different subsystems in the city.

SMART LOGISTICS

The model of smart city points out six areas (1) smart economy (2) smart mobility (3) smart environment (4) smart people (5) smart living and (6) smart governance. The presence of 'mobility' is an important dimension that describes availability of communication, tele-informatic infrastructure, innovative and safe transportation systems. The Smart cities need logistics with proper infrastructure, information nets and effective business models. The smart logistics refers to use in the implementation of logistical tasks, new intelligent technologies with fully automated processes. The smart solutions which contribute to the effective functioning of the smart logistics include - intelligent transportation systems, autonomous logistics (systems providing unmanned, autonomous movement of people and cargo with minimized contribution of human labour), physical internet (the ability to the most effective movement of goods to any place in short time providing stability of global mobility), intelligent cargo (loads having knowledge about where are, where they go, when they should be there and who should reload them) and self-organizing logistics (without any big effort of engineers and managers).

SMART MOBILITY

The biggest influence of Smart logistics for realization of Smart city concept is visible in the area of "*smart mobility*" which means huge web of connections, transport and communication with big speed of connecting all of the resources of the city. Smart mobility is connected with implementation of ICT (Information and Communication technologies) and Intelligent Transport Systems (ITS), in which the key role is to improve safety, increase efficiency of transport processes & environment protection and guarantee safer, more coordinated and smarter use of transport network. The ICT support in managing the applications that control the traffic lights of crossing, messages that are shown on the boards with

changeable data and automatic identification of vehicles. Further, the management of public transport by the monitoring and controlling fleet will become easier using GPS data with the real time access of speed and location information from users. The Vehicle to Vehicle (V2V) communication and Vehicle to Infrastructure (V2I) connection will prevent traffic jams and also allow lower use of Petrol and emission of exhaust fumes.

SMART ECONOMY

The smart logistics will facilitate "*smart economy"* as the intelligent city shows up high productivity, innovative climate and elasticity of labour market. The well planned economical structure of the city that makes the smart city attractive location for industry, trade and services. To support smart economy, the factories are to be designed according to Industry 4.0 standards with self-organized systems of production and management of cyber-physical systems. The availability of real time manufacturing information can achieve fast physical flows thereby contributing to the cost effectiveness of the economy.

SMART ENVIRONMENT

The smart logistics is necessary to implement "*smart environment*" which optimize the energy use and decrease the emission of pollution levels. The intelligent ways of transportation, which are run by renewable energy sources stop greenhouse gases emission. The intelligent transport system (ITS) allows higher safety in transportation, shorten time of travel and reduce inconveniences like pollution and noise, increase in bandwidth of streets, improvement of safety of traffic, decrease in the time of travelling and use of energy, reduction of costs of management of traffic supply chain and improvement of quality of natural environment.

SMART LIVING

The "*smart living*" is another feature of the smart intelligent city, which create availability of places for studying and culture. Smart living support transportation solutions like intelligent parking that use systems of boards with changeable data and give information about free parking places. The improvement in quality of life solutions include supporting traffic safety with use of smart city brake support, which is to prevent happenings such as crashing by the back of the vehicle due to a sensor

which monitors road in front of the car. The smart logistics and intelligent systems of managing of traffic support collect the information about the number of cars on the streets, number of passengers on the bus stops, difficulties in traffic, weather conditions etc. The information is analyzed and propose solutions for alternate options thereby avoiding overloading on the streets, decrease use of fuel and CO_2 emissions.

MANAGEMENT OF INFRASTRUCTURE

Smart Logistics supports management of infrastructure of the city in the real time as more and more urban agglomerations are heading to be smart. Efficient management of the urban infrastructure, monitoring of the city, environment pollution, managing of traffic, lightning of the city in a considerable way causes reduction of costs and decrease of environmental pollution. The benefits of smart technology and advantages they bring to transportation within a smart city are numerous as the smart transportation is safer, better managed, more efficient, cost effective and provides rapid insights. The additional benefits that the general public, local governments and world at large can enjoy are Security, Environmental Considerations and Supply Chain Resiliency. Few disadvantages may come to the surface are the power consumption owing to lot of sensors attached to the moving objects and the data management with more responsible laws and policies.

CONCLUSION

As our global economy is becoming complex and interconnected, the logistics and transportation industry must be at the forefront of the latest technological innovation. The smart logistics solutions will remain a powerful ally in this process, giving the industry the tools, it needed to remain lean and agile in an ever-changing world.

BIOGRAPHY

V V V Prakash was born in Andhra Pradesh, India in the year 1971. He is currently working in Bechtel India Pvt. Ltd, Gurugram as Engineering Group Supervisor in Control Systems Engineering. He has been working on OG&C, Energy, Infrastructure and Mining & Metal Projects for the last 27 years. He was ISA Delhi chapter member since 2008 and in the past submitted Technical papers on "Green House Gas Emissions monitoring" in ISA conference on Power Automation Technology event POWAT-2012, "Dynamic Simulation analysis for efficient control of centrifugal gas compressors" in ISA Power and Petroleum Automation Meet - PPAM 2019.

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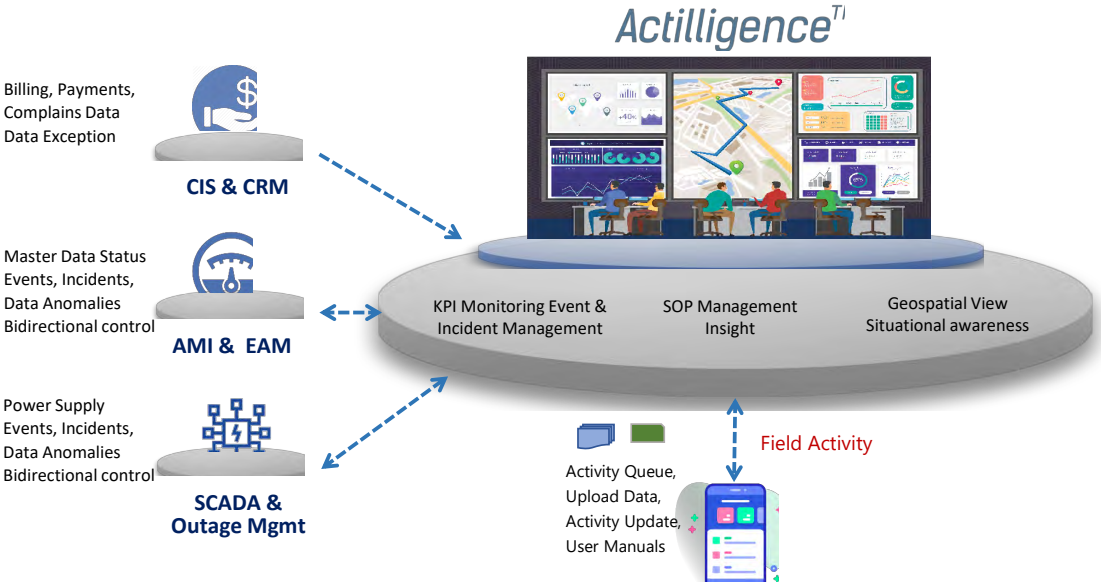
Utility Operations Center

Actilligence platform centralizes data collection, intelligent analytics and incident resolution while democratizing decision making



Key Outcomes

- Assistance in potential cost savings
- Situation awareness of Utility operations
- Data driven analytics for decision support
- Enhance customer satisfaction
- Optimize usage of electricity
- Emergency response systems

- Proactive asset and facilities management to minimize failures
- Effortlessly manage the smart infrastructure and service delivery
- Respond to emergencies with centralized command and control
- Seamless real time interactions with customer through multiple channels
- Future-proof ICT infrastructure that can scale both horizontally and vertically
- Quick RoI with premium positioning, enhanced productivity and resource conservation
- "Thus, position the utility as a premium destination"

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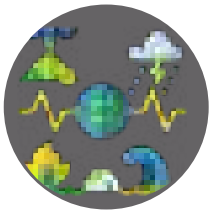
OUR DIFFERENTIATOR: MULTI-PURPOSE Utility Operations Center (UOC)



In Disaster Situation (Utility Scale)

- To provide accurate early warnings to all stakeholders and ensure their effective dissemination
- To forecast impact of disasters and help mobilize resources upfront, evacuate people from high impact areas and in turn minimize casualties and service outage during disasters
- Carry out competent Emergency Operations Management
- To improve the response time, coordination amongst various agencies during disaster and faster restoration of services post disaster
- Improve community understanding of risks in order to enhance their resilience in the face of disaster

In Emergency Situation (Area based)

- To provide a common operating picture for all emergency services departments with clear action points for joint action
- To forecast impact of emergency and help mobilize resources upfront, evacuate people from high impact areas and in turn minimize casualties and service outage during disasters
- Carry out competent Emergency Operations Management
- To improve the response time, coordination amongst various agencies during disaster and faster restoration of services post disaster

In Normal Situation (Department / Person)

- Enable better functioning of utility administration in daily operations
- Improve response time towards customer complaints, which in turn will lead to customer delight and satisfaction
- Enable various channels/ online tools for customer interactions with utility administration for issue reporting and resolution
- Enable better inter-agency coordination, within various administrative bodies to improve service delivery and governance transparency

UTILITY OPERATIONS CENTRE COMPONENTS

Map based Visualization and MIS layer

- Integrate with GIS and map information to dynamically update information on the GIS maps to show status of resources
- Executive Dashboards, KPI & Performance Monitoring for utility Administrators, Operators and managers with a management dashboard that provides a real-time status and is automatically updated when certain actions, incidents and resources have been assigned, pending, acknowledged, dispatched, implemented and completed

Unified Contact Centre Collaboration Platform

- Facilitate collaboration between various stakeholders and aid in grievance redressal of customer • Ability for Stakeholders with various smart devices (smart phones, Laptops, Analog Phones etc.) to invoke/participate in a joint discussion

Pre-Integrated Standard operating procedures for Incidents and Alarms

- Ability to invoke an un-limited number of configurable and customizable standard operating procedures through graphical, easy to use tooling interface
- The SOP editing interface provides configuration by sections involving 1) Manual Activity 2) Automation 3) If - Then - Else, 4) Notification

Mobile workforce management system

- Interact with field officers of the various departments and utility administration to resolve and escalate incidents
- Trigger individual Tasks/Activities which involve actions like sending a notification/message, dispatching a crew for inspection or fixing, through a Mobile Work Force Management System

Analytics Platform

- Provides descriptive, predictive and prescriptive analytics by consuming data from heterogeneous data sources of various utility infrastructure to unravel the patterns that are previously hidden
- Artificial intelligence-based Smart Infra analytics platform module to maximize business value through advanced machine learning capabilities

Data Normalization Layer through IOT Platform

- Aggregate and normalize data coming from different devices and provide secure access to data using data API(s) to application developers

GEOSPATIAL VIEW

Web-based Geospatial View, CAP-based alerts and events from smart elements and incidents from CAD system will be represented as part of emergency-communications, and it can be used by multiple operators simultaneously and supports multi-departmental operation using Region assignments. Geospatial representation by using geospatial-mapping facilities provided through Google Maps, ESRI IGiS, and Bing. Support GML and KML standards for data representation and import.

Along with mapping functions, Geospatial View also combines multiple means of monitoring and tracking field Units and resource tracking, Individual field level device functioning status with alert pop-up is available, and positions displayed on the Situation map, with location configuration for unmovable assets can be incorporated based on business requirement.

INCIDENT MANAGEMENT

The incident management software shall have dedicated incident log screen, which provides situation decision guidance support. Utility Operations Center application will support for receiving different types of VMS alerts. The application provides the following information related to VMS alert:

- Shows the Severity of the alert
- Time the alert was created
- Description of the alert
- Device which created the alert
- It will have provision to facilitate the operator to locate the meters on GIS map
- Provision to amend the alert
- Collaboration chat against specific incident for the stakeholders

Objectives

- Department wise KPI Monitoring to measure progress against targets
- Continuous drive for improvement across all departments with a dedicated team
- Provide users with SOP's , Notifications and Alerts of Incidents with Geographical location which will enable the utility administrators to respond dynamically and make utility operations SMART
- Role based access control to provide access to view/ edit master data according to department hierarchy.
- Multi-level video rveillance at the utility command center to monitor events realtime, manually or automatically by Sensor feeds.

SOP MANAGEMENT

SOP is a set of instructions to respond to events or incidents and carry out routine operations in an organized manner. These enable to achieve efficiency, quality output and uniformity of performance while reducing miscommunication and help involved organizations to achieve complete control over the task along with escalation process.

Features of SOP Authoring

- Granting access to SOP definition portal page
- SOP actions and required roles
- Configuring and launching SOPs
- Viewing SOP

INTERACTIVE VISUAL ANALYSIS

Fluentgrid Actilligence™ offers impeccable quality of Visual Analytics with features including but not limited to the following:

- Users are self-reliant and can immediately access, analyze and visualize any data through simple user interfaces resulting in complex analysis
- Interactive visual analysis with drill through, lasso filtering, zooming, and attribute highlighting for greater insight.
- Out-of-the box library of interactive visualizations - including geo-mapping, heat grids and scatter/bubble charts.
- Specialized, visualization plug-ins delivers "the art of the possible" for advanced visualizations.
- Extreme scale in-memory data caching for speed-of-thought analysis of large data volumes.
- True mobile experience with support for native gestures and complete analytics capabilities, including content creation.

LIVE DASHBOARDS

Fluentgrid Actilligence™ Live Dashboard is a set of visualizations, different type of charts from one or more categories presented in a managed way, which makes user easy to draw an insight and analyze without any need of expertise in analytics.

A dashboard contains visualizations from multiple reports and it is interactive tool also. As user can view the information ore deeply and drill down the data see the information up to reachable level.

Objectives

- Command and control across all functions to drive actions towards a common goal
- War room facilitation during emergencies with people from various departments coming together to attend to an emergency
- Inter-department coordination for faster issue resolution and clearances to speedup works
- Data correlation and analysis to alert on certain events, identify exceptions, observe patterns and predict trouble
- Data visualization for easily grasping critical information faster than usual

BUSINESS RULE & POLICIES

Configuring business rules for air quality, street light and bin monitoring, water SCADA, energy data etc. the rules are deployed into the rules repository. Rule engine uses these rules to determine abnormality. The rules can be changed using a web-based user interface whenever there is a change in rules.

Data receives from various sources like street lights, water SCADA, Energy and Air quality sensors through MQTT protocol. Once the data received, ETL tool executes the Spark Jobs to apply the business rules.

EVENT MANAGEMENT

An event is anything important that happens or is envisaged as happening. Events generated by IoT sensors or component management systems when any defined/measured parameter exceeds the set threshold. Events from all the sources are aggregated and CCC operator is alerted. The operator can analyse and decide whether to accept or dismiss the event.

The event management occurs in four steps: monitor, analyse, plan and execute. All the log monitoring, video monitoring and the event feed come under the monitor section. The events get correlated and will be assigned each a ticket. The event correlation tool can correlate events from multiple monitoring sources.

Complex event processing combines data from multiple sources to infer events or patterns that evince more complicated circumstances. Event processing occurs when dealing with either one or more events with the purpose of recognizing prioritized events from the event cloud.

When multiple references to different events are detected, such events, the events may spread over different types and through a specific time. Based on the nature of data/information, the event would be stated whether it is complex or not to a user.

Today, CEP is used for various use cases, including:

- Air quality: Air quality data analysis and detection of the polluted area in the utility on a real-time basis.
- Water SCADA: detection of abnormal usage.
- Energy: detection of abnormal usage.
- Street Light: detection of non-functional streetlights.

COMPREHENSIVE SOLUTION FOR REPORTING

- Our reporting capabilities span the entire continuum from self-service interactive reporting to high volume, highly formatted enterprise reporting.
- Intuitive web-based interactive reporting for business users.
- Rich graphical enterprise report designer for power users.
- Output in popular formats: HTML, Excel, CSV, PDF and RTF.
- In-memory caching for fast results.
- First to market direct reporting for NoSQL

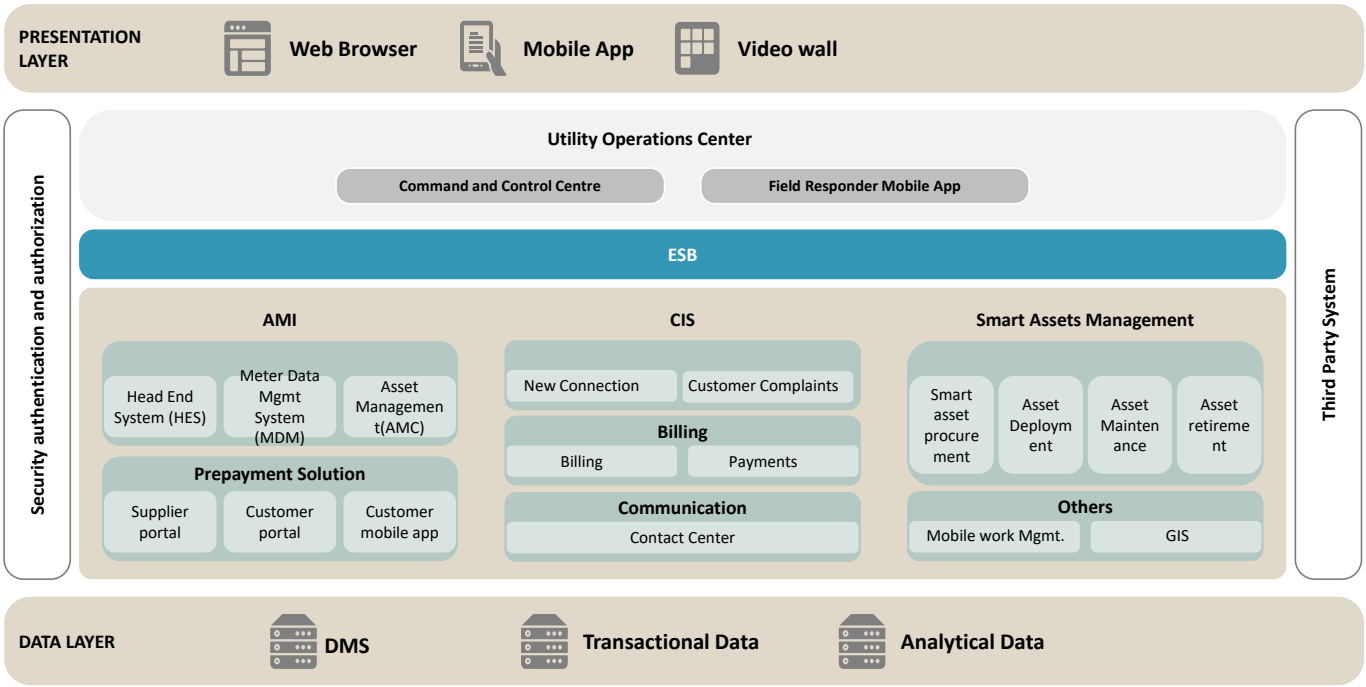
Fluentgrid Actilligence™

Fluentgrid Actilligence™ is the foundation on which the Utility Operations Center solutions for utilities are built. It comes with loosely coupled federated architecture where granular functionality is broken down into independent modules minimizing inter-module dependencies. Following diagram illustrates how Fluentgrid Actilligence™ components come together for UOC solutions in Smart Infra.

Fluentgrid Actilligence™ for ICCC is based on an n-tier Service Oriented Architecture (SOA), built using industry open standards and technologies to provide maximum benefit to customers without compromising on robust security.

Solution Architecture - Utility Operations Center

A robust solution architecture that effortlessly integrates in your environment...



Functional & Presentation layer: This layer provides easy access to utility operations center users and field staff through web, mobile or video wall interfaces. Users have flexibility to customize the views to suit their needs

- List and Map View: Events/alerts and incidents across the field devices and functional systems throughout the utility are available for user/operator view along with location, source and evidence. Also available are the incidents directly reported, social media complaints and the system generated incidents thought pattern analysis.
- Operation Dashboard: is an interactive executive dashboard with various department level sub-dashboards. Data coming from multiple departments is analyzed to identify abnormal events, patterns and exceptions and alert the concerned for further action.
- KPI Monitoring: empowers executives to define and closely track progress on broader parameters of utility transformation. It also enables the utility to benchmark against standards and get certified for compliance by international bodies such as ISO

Business layer: Business layer is the brain and soul of the Actilligence platform. It holds the business logic an engine that systematically process the data received into actionable information, insights and suggestions.

Complex Event Processing (CEP) & Correlation: allows streaming of large sets of utility data to bring out events of relevance. Broad steps involved in processing an event include

- Stream Processing
- Business Process Management and Correlation
- Business Rules
- Notification Service

Incident/Alert Management

- Instant alerts and notifications from field devices, utility systems and real time data analysis
- Automatic conversion of business exceptions into actionable workflow tasks (pre-configured SOPs)

SOP (Standard Operating Procedure) Management

- SLA tracking and escalation for each workflow task
- Web or mobile based workflow issue resolution
- Mobile field service integration for field activities

Data Normalization & Analytics Layer

- Advanced Data Analytics: Doing statistical analysis, machine learning, predictive and prescriptive analytics, social media analytics on utility operations data and feed the output such as anomalies and exceptions to incident management system to track them to closure, and insights to operation dashboards and performance monitoring cases.

- Business Analytics: Doing real time analytics of the normalized data from external utility systems, machine generated data, field devices, sensors, social media, etc. and provide insights for utility operations. For example, route optimization for waste bin dispatch, traffic clearance emergency dispatch, number plate recognition, utility planning cases such as building permissions, event planning, etc., emergency response and relief after the event, utility outage management, utility usage forecast, epidemic isolation/prevention of spread, etc.

Integration Layer: Seamlessly access and manage data from all the external systems such as utility ERP management systems, utility management systems, asset management systems, transport management systems, traffic management systems, social media streams, customer service systems, etc., and field devices (provisioned with access) which flows into Fluentgrid Actilligence™.

- API Manager: Enable easy and standards-based access to existing utility systems and facilitate exposure of utility APIs to third-party service providers and users who can bring meaningful services on top of the data what utility hold.
- Enterprise Service Bus: For managing integrations and reliability among disparate systems and different messaging formats and standards.
- IoT Gateway: Open standard IoT platforms to manage access and control of IoT devices such as sensors, field devices, public messaging systems, video surveillance, etc. It allows us to easily and securely
    - Provision and control devices
    - Collect and visualize data from various messaging standards. E.g. MQTT, CoAP, HTTP, LoRa, Zigbee, OPC UA, etc.,
    - Analyze device data and trigger alarms
    - Deliver device data to other systems
    - Enable use-case specific features using customizable rules and plugins

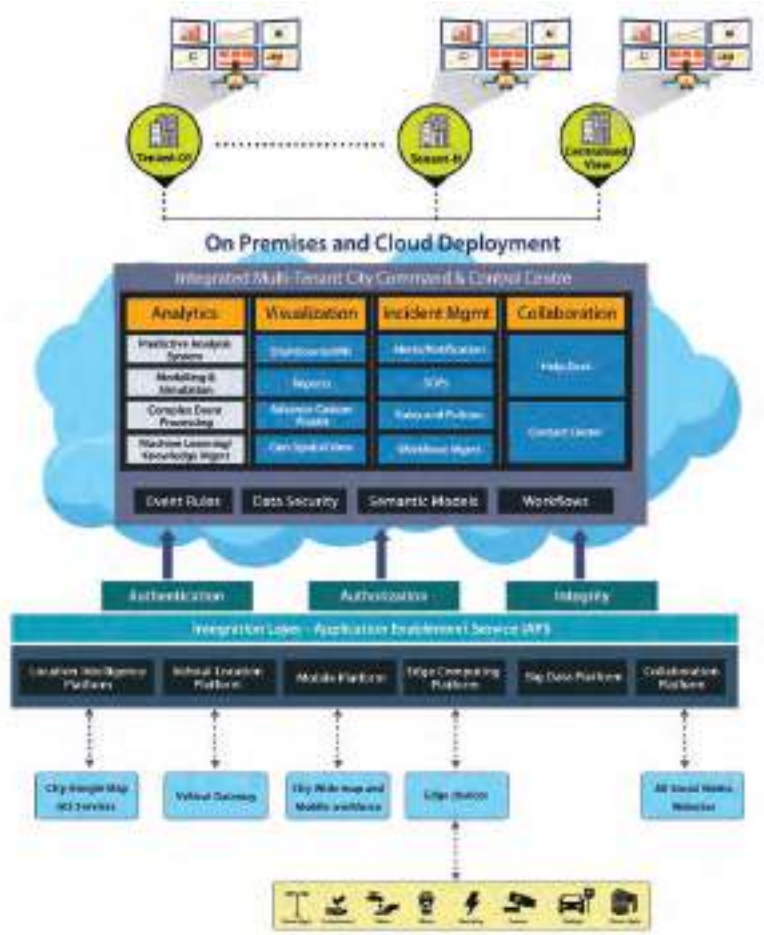
Cloud and multitenancy support

Hub and spoke model is the most common way of deploying a multi utility implementation. Fluentgrid Actilligence™ architecture allows for adding new utilities to existing platform on the fly with minimal configurations and available as

- Multi-Tenant Platform to support multiple cities as a group into single deployment
- Cloud based Platform as a Service (PaaS) or Software as a Service (SaaS) for Data Center and Disaster Recovery Center for all Smart Infra in a group

Multitenant Functionality	Description
Default utility	Fluentgrid Actilligence™ allows defining default utility with SOPs and other utility level configurations. This can be a base utility that other new cities that are added can inherit from
Adding New utility	Fluentgrid Actilligence™ has the provision to create a new utility on the fly by cloning an already existing utility or by inheriting from default utility
Attaching devices and smart elements to a utility	Device and smart elements can be attached to a utility through a simple onboarding process. Devices can be disengaged from a utility and reassigned to another utility
Services Consumption Metering	APIs/Services consumption is tracked at utility level pay as you go model can go to individual utility level

MULTI-TENANT ARCHITECTURE



Functionality	Description
Default Utility	The CCC allows for defining a default utility with SoPs and other configurations. This forms as a base utility that other new utilities that are added can inherit from
Adding a new Utility	CCC can demonstrate the ability to create a new utility on the fly in CCC. This can be done by cloning an already existing utility and copy the SoPs and other utility specific artefacts to the new utility or by inheriting from the Default utility
Attaching Devices to a Utility	Devices and Smart Elements can be attached to a utility through an onboarding process. Devices can also be disengaged from a utility or re-assigned to another utility.
Consumption through API manager	Shows API consumption for both the utilities so that Services billing is done as a pay as you go basis at an individual utility level
Comparative Utility Analytics	ISO 37120 defines and establishes methodologies for a set of indicators to steer and measure the performance of utility services and quality of life. This will help utilities to assess their performance and measure progress overtime, with the ultimate goal of improving quality of life and sustainability. The standard's uniform approach will enable cities to seamlessly compare where they stand in relation to other utilities.

FLUENTGRID
seamless digital transformation

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ISA Delhi Section

Setting the Standard for Automation™

RELAYability

Technology Concepts of Control Relays in Automation

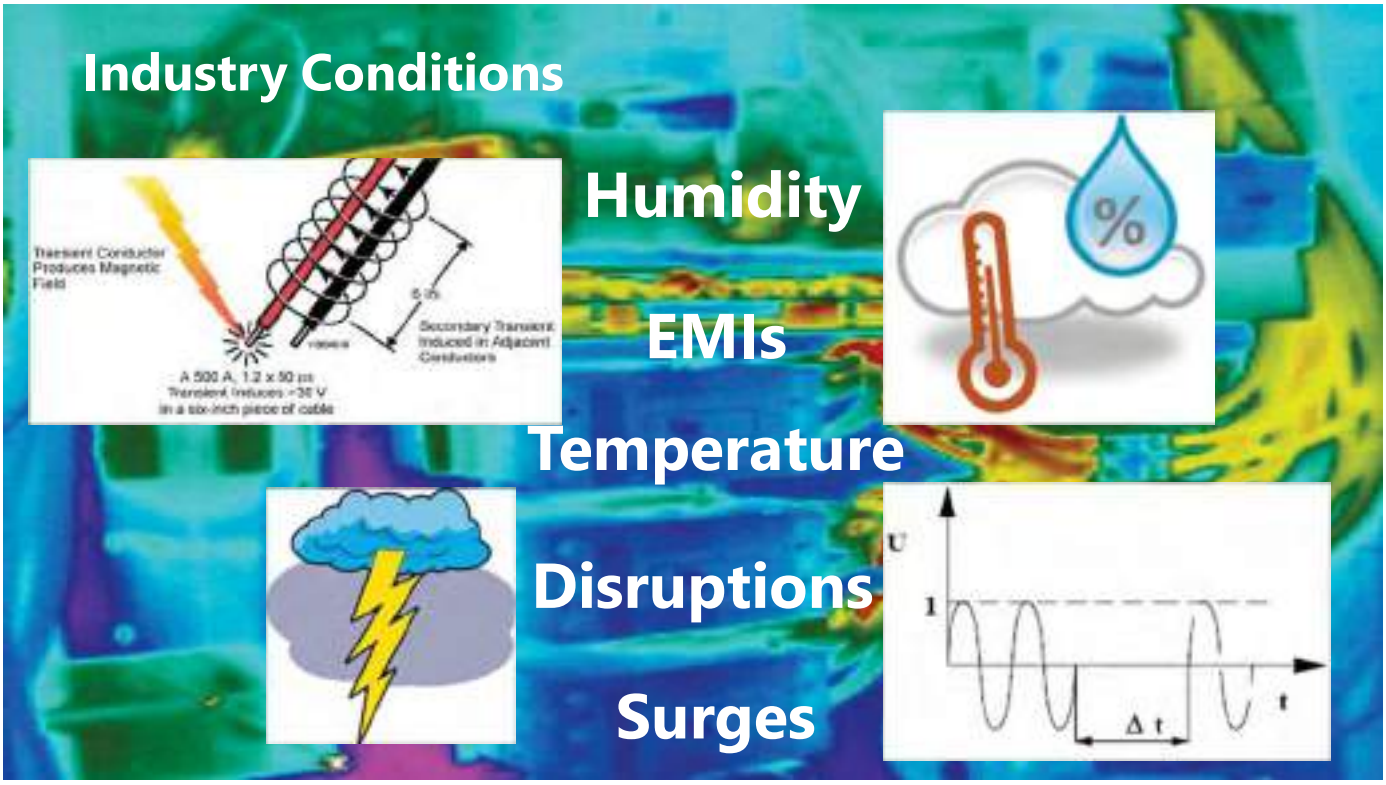
ISA-D: "TOMORROW's OPPORTUNITIES with TODAY's Automation LEADERS (TOTAL-2021)

Control System Components

Reliable performance and working of components in Control Systems

- Relays,

INDUSTRIAL GRADE



Few important parameters to consider while choosing generic industrial grade relays

- ❑ **Temperature** — Ambient temperature range | °C | –40...+85
- ❑ **Electrical Life as per load type** — Electrical life at rated load AC1 | cycles | 200 · 10^3
- ❑ **Di-Electric Strength** — Dielectric strength between open contacts | V AC | 1000
- ❑ **Surge Impulse capacity** — Rated impulse voltage (surge) differential mode (according to EN 61000-4-5) | kV (1.2/50 µs) | 4
- ❑ **MTTF Value – Mean Time To Failure** — This can be expressed in terms of MCTF (Mean Cycles To Failure). With knowledge of the frequency of operation f (cycling rate, expressed in cycles/hour) of the relay within the equipment, the number of cycles can be simply transformed, using the relation MTTF = MCTF / f, into a respective time (expressed in hours), giving the effective MTTF value for the relay in that application.

Considering Relay's Temperature ratings

(Screen Shot of a Typical relay Data-Sheet)

Item	Pole	Model	Carry current	Dielectric withstand voltage	Insulation resistance (see note 2)
Screwless clamp terminal socket	2	PYF08S	10 A	2,000 VAC, 1 min	Less than 1,000 MΩ
	4	PYF14S	5 A		
Track-mounted socket	2	PYF08A-E	7 A	2,000 VAC, 1 min	1,000 MΩ min.
		PYF08A-N (see note 3)	7 A (see note 4)		
	4	PYF14A-E	6 A		
		PYF14A-N (see note 3)	5 A (see note 4)		
Back-connecting socket	2	PY08(-Y1)	7 A	1,500 VAC, 1 min	100 MΩ min.
		PY08-02			
	4	PY14(-Y1)	3 A		
		PY14-02			

Note: 1. The values given above are initial values.
2. The values for insulation resistance were measured at 500 V at the same place as the dielectric strength.
3. The maximum operating ambient temperature for the PYF08A-N and PYF14A-N is 55°C.
4. When using the PYF08A-N or PYF14A-N at an operating ambient temperature exceeding 40°C, reduce the current to 60%.
5. The MY2(S) can be used at 70°C with a carry current of 7 A.

Industrial PLC/DCS panels need Components to withstand minimum 60 Deg C. So that even if there is an Aircon failure for upto 48 hours the System should operate without any stress.

Is this an industrial grade relay??

Components like Relays need to be even rated higher for operating temperature as they are themselves a source of heat generation.

Electrical Life of a Relay

(Another picture from a standard relay data-sheet)

Endurance		(switching frequency: 18,000 operations/h)
	Electrical*1	500,000 operations min. (rated load, switching frequency: 1,800 operations/h)

Item	Number of poles	2 poles
Failure rate P value (reference value)*2		1 mA at 5 VDC
Weight		Approx. 35 g

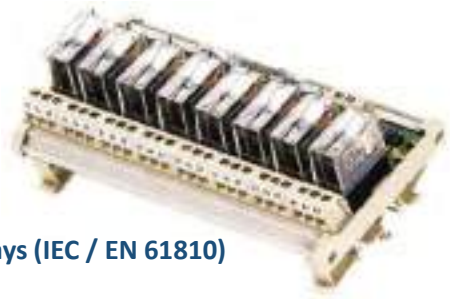
Note: These are initial values.
*1. Measurement conditions: 1 A at 5 VDC using the voltage drop method.
*2. Measurement conditions: With rated operating power applied.
Ambient temperature condition: 23° C
*3. Measurement conditions: For 500 VDC applied to the same location as for dielectric strength measurement.
*4. Ambient temperature condition: 23°C

Electrical Life Time

A typical rating of Electrical Life of an INDUSTRIAL relay is tested at not less than 70 deg C (definitely not at 23 Deg C)

The Operating Life Time of a Relay must be specified along with the Rated Current, so that the system designer and end user can optimally get an industrial grade relay (not a commercial grade version)

PCB Mounting Multi-Channel Relay Modules - A Reality Check ?



- No Compliance with industrial standards for Interposing Relays (IEC / EN 61810)
- Missing Test data i.e. EMC, Temperature Withstand, Dielectric Strength
- Always a scope for lowering quality due to L-1 pressure
- A fault in the PCB Track/Soldering leads to failure of entire card
- The Soldered Components are not touch proof (Di-electric strength ?)

Reliability (MTTF & MTBF)

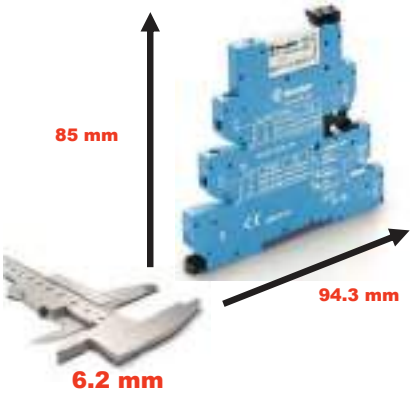
Relays are generally considered to be non-repairable items and as a worn relay is replaced, its MTTF (Mean Time To Failure) value is appropriate in calculating the MTBF (Mean Time Between Failure)

For any given application, with the knowledge of the frequency of operation the effective MTTF value can be easily demanded and calculated.

Cable Ties !!

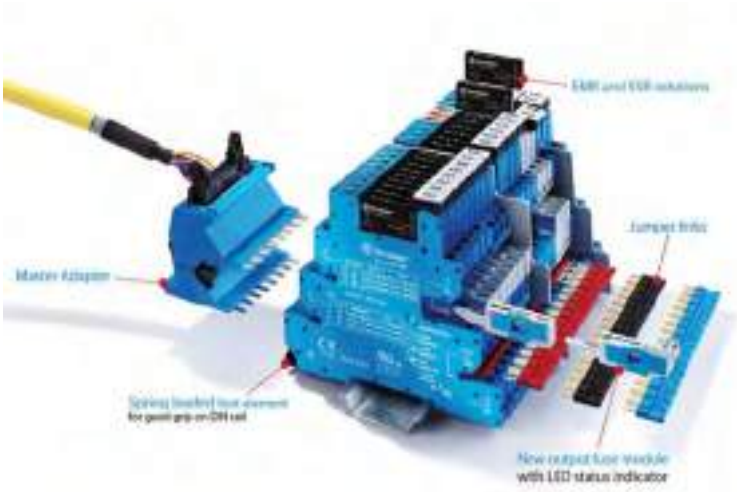
Technology Shift in Auxiliary Relays

INDUSTRIAL GRADE ?



New Generation Industrial Relays

Evolution is advantageous



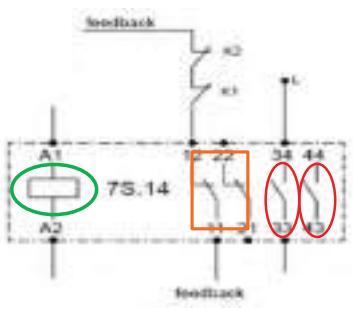
- Saves Space & Wiring Cost
- High Electrical Life at 70 Deg C
- Low power consumption saves energy
- Powerful rating – 6 A EMR & SSR.
- Reliability with polarity independence
- FUSE protected output for Digital I/Os
- Easy, quick installation and less wiring
- More numbers of I/Os can be accommodated per cabinet
- Overall lesser number of panels in a project due to the high density modular technology

Different APPLICATIONS demand different RELAYS

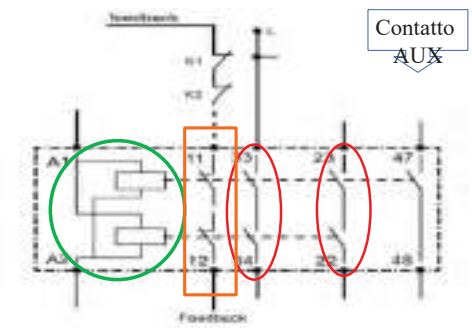
- SAFETY Relays
- DC Switching Relays (Shunt Trip Coil circuits)
- Contact Multiplication Relays
- Monitoring Relays
- Timer Relays
- Wireless Relays
- Solid State Relays

Difference between SIL2 & SIL3 Relays

- SIL2
- A SIL2 device consists of: 1 RELAY 1 COIL 1 CONTACT NO FOR EACH EXIT (or CHANNEL) 1 OR MORE CONTACTS NC



- SIL3
- A SIL3 device consists of 2 RELAYS FOR EACH OUTPUT 2 PARALLEL COILS 2 CONTACTS NO IN SERIES FOR EACH CHANNEL 2 NC CONTACTS IN SERIES

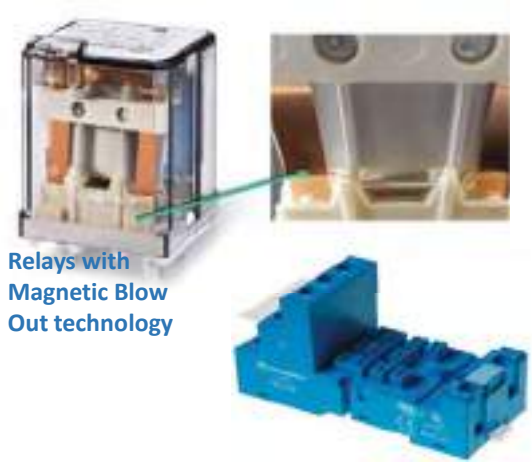


Safety Relays - How to Choose SIL 2 and/or SIL 3

- For a SIL 2 Circuit use ONLY a SIL 2 Relay (not SIL 3 – AVOID ADDITIONAL wiring, space, cost and energy consumption, heating)
- Check for the type of Load (Inductive/Resistive)
- Look into Inrush currents for DO applications (AC/DC Loads)
- Self / Third Party Certifications i.e. TUV / EUROFINS / Exida etc
- 60 Deg C Operating Temperature (48 Hrs without aircon)
- Gold Plated Contacts for DI applications (>10mA load)

Safety Applications can be optimized by adopting the right approach towards the Safety Circuits in use

Power Relays for High Current DC applications - Contactors, Shunt trip / Motor Trip coils



Relays with Magnetic Blow Out technology

- ✓ **Specialized relays technology to switch 110VDC or 220VDC Loads**
- ✓ **Such DC loads are inductive and need DC 13 rated Relays**
- ✓ **Contact Material of AgSnO2 best suited**
- ✓ **Min. 70 ˚C rated for reliable operation**
- ✓ **For safety circuits MTTF calculation to be provided by the relay manufacturer**

Special Purpose Industrial Grade Relays

Solid State Relays

Used for applications with:

- Higher Switching Frequency
- Higher AC/DC Inductive Loads
- Faster reponse time needs
- DI Load currents less than 1mA

Contact Multiplication Relays

Used for applications with

- 2 or more changeover contacts
- Electrical Panel Interface
- Outdoor Panel applications
- Replacement of Contactors

Gas Resistant Relays

Special versions for zone 2 installations with presence of GAS.

DIGITAL Relays for - Voltage & Current Monitoring

Programmable universal voltage monitoring Relay

To monitor critical applications where AC/DC voltage detection within a safe limit is essential

i.e. non-UPS based Control Voltage Supply etc

Programmable universal current monitoring relay

To monitor critical applications where AC/DC current detection within a safe limit is essential

i.e. cooling fan failure detection etc

71.91

Thermistor Relay

For Motor winding Temperature detection with PTC short circuit detection and PTC wire breakage detection

Timer Relays for Plant Lighting Automation

All-year round controlling the Switch-On/OFF timings of outdoor lights as per Sun rise and Sun set time of the plant location

Digitally/Mobile programable "Astro-time" setting of the relays with INDIAN PIN Codes

Wireless Relay Technology for Building Automation

Multi-way controllable WIRELESS relays for SMART living

Suitable for plant buildings & offices

Control through SMART PHONE

Control through WIRELESS wall switches

Remotely controllable relay from anywhere around the GLOBE through Wifi GATEWAY

Smart Programmable Multi-Functional

BLUETOOTH Control through portable remote switches

VOICE Control through voice instruction through Google Assistant or Amazon Alexa

RELAYs to the Core and much...More

QUESTIONS

A SWITCH in Time Saves Nine!!

FROM SUBSEA TO REFINERY - CONTROL IS KEY

Presenter: Mr Mohd Nazir & Mr Ahmad Nazrin

Tracerco Limited (subsidiary of Johnson Matthey Plc , UK)

& EIP Technologies Pvt Ltd

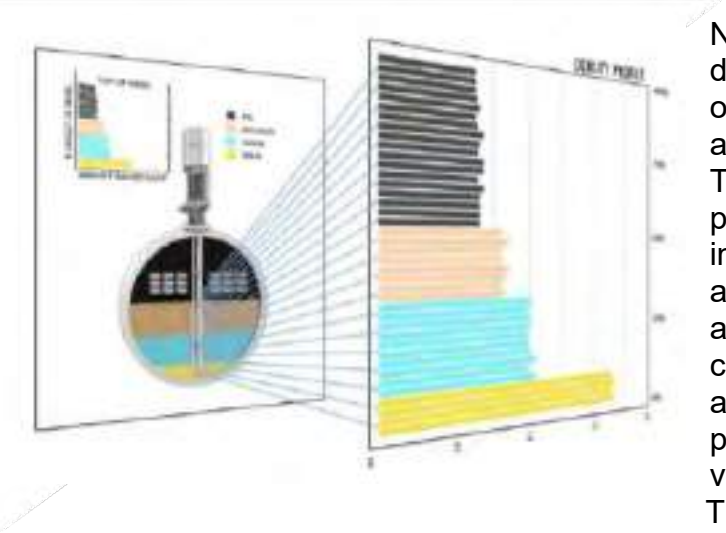
Introduction:

Evolution of Nucleonic Measurement Technology to meet the ever-changing environments along the oil and gas processing stream. The technology has been adapted from its initial development to identify process characteristics within the upstream separation environment, to quantify chemical usage within the refining sector, through to its deployment in subsea separation applications. The technology effectively enables the user to see through vessel walls and have an exact understanding of what is happening within the vessel throughout the entire operation in real time.

Whether deployed for slurry management, chemical utilisation, reliable repeatable measurement or in a hostile environment, the application defines the exact solution to be offered. Only once a clients' full requirements are understood can a bespoke offering be designed to meet their needs. This approach adopted by nucleonic measurement ensures a client receives a solution that is fit for purpose and virtually maintenance free.

Highlighted results include increased throughput, reduced downtime, and the associated economic benefits this can bring.

Control is key- (Nucleonic Measurement Technology):



Nucleonic Profiler systems have been developed and deployed to enable operators to see the formation of emulsion and deposits in a Vessel(s) in real-time. This critical process measurement provides the data required for operators to implement actions to optimise production and reduce the impact on plant operation and the environment. The instrument comprises a two (or three) dip pipe assembly, similar to a thermowell that protrudes into the vessel from a flanged vessel connection.

The dip pipe assembly is supplied in accordance with the vessel design criteria and ensures the items placed within are free from contact with the process. One of the mentioned dip pipes houses a vertical array of sources,

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Presented at TOMORROW's OPPORTUNITIES with TODAY's Automation LEADERS
(TOTAL-2021); http://www.isadelhi.org

similar to those found in domestic household smoke detectors. In domestic smoke detectors, it is the alpha particle that is stopped by the presence of smoke, which activates the alarm, however the source also emits a weak gamma energy. This weak gamma energy is enough to pass through the dip pipe assembly and process fluids and is then detected by a detector installed in the other one (or two) dip pipe(s).

In order to obtain the required measurement accuracy, the system adopts a collimated design which ensures the detecting element is focused at a particular elevation. This design also allows for ease of isolation, with a single movement isolating the system providing safe access into the Vessel(s) for routine maintenance and inspection requirements. The Profiler has been adapted to meet clients' ever-changing and more demanding requirements. This includes reducing the lower temperature range so that it can be utilised within the LNG market and increasing the higher temperature limits so that a full picture and understanding of what is happening within a high temperature Vessel(s) can be understood. Driven by clients' needs for a no moving parts, no maintenance solution, the technology has also been utilised in a number of subsea separation applications in accordance with ISO 13628-6 subsea production and control systems. The Technology can save the facility several million dollars per year.

Leveraging IIOT to Upgrade Existing Industrial Automation and Control Systems

CKS TARUN

Keywords

IIOT, Wireless Gateway, THUM Adapters, WirelessHART, Honeywell EPKS DCS

1. Introduction

Industrial Automation and Control Systems (IACS) play a critical role in the functioning of process industries even though their share in the total capex of the project is miniscule. Modern control systems have the capability of not just monitoring, controlling and starting up/shutting down the processes but also leveraging the advanced diagnostics and data available from smart field instruments and third party systems.

Data and diagnostic information may be assimilated by control systems through the various popular protocols like HART, FIELDBUS, PROFIBUS etc. Either due to organizational policies or budget constraints, many of the projects have not been able to leverage the full capability of modern control systems even though the field instruments are smart and capable of providing more data.

It is becoming increasingly relevant to leverage IIOT not just to diagnose problems early but also to leverage the big data ecosystem for increasing competitiveness and bringing about digitalization.

Vallur Thermal Power Station is a 1500 MW (3X500) Thermal Power Project setup under NTECL (NTPC TamilNadu Energy Company Limited), a JV of NTPC and TANGEDCO. The project uses sea water for condenser cooling. Reverse Osmosis based sea water desalination plant of 19.8 MLD capacity caters to the captive potable/dm water requirement of the entire project. Honeywell's Experion Process Knowledge System R311.2 DCS has been installed for main plant BOP systems along with offsites.

2. Project Details

The genesis of the pilot project was the need to optimize cost and increase reliability of the automation systems installed at the sea water desalination plant. To reduce downtime, equipment replacement and manpower cost, the need was felt to shift from prevailing preventive maintenance procedures to predictive maintenance regime. Establishing predictive maintenance practises required usage of advanced data and diagnostics from various smart field instruments installed at site. Most of the smart instruments installed had capability to communicate over HART protocol.

Honeywell's EPKS DCS has the capability to assimilate this additional data coming from field through HART protocol but the version installed at Vallur site did not have this capability owing to non-usage of HART compatible DCS IO modules. This presented a big challenge as the DCS was not nearing it's end of life and replacing IO modules with HART compatible ones was unviable. This would not only incur huge cost but would also be problematic from spare management point of view as the existing inventory of older IO modules would become redundant and it would also entail building up additional stores of HART compatible modules.

IIOT schemes, wherein wireless sensor networks bring data from various smart field instruments without major changes in the existing DCS presented a good alternative to the proposition of replacing certain DCS IO modules. After detailed discussions with various vendors, Emerson's THUM adapters and Wireless Gateway 1420 working on WirelessHART protocol were chosen for implementing this pilot. The THUM adapter provides flexibility in utilising the existing wired smart instruments deployed in the field while the 1420 gateway provides easy integration with existing DCS. The project was conceptualised to be implemented in 3 phases as follows:

- Phase1 - Standalone WirelessHART network
- Phase2 - Integration with Honeywell EPKS DCS
- Phase3 - Introducing completely wireless field instruments

The paper mainly focuses on Phase1 and 2 of the pilot project with a brief cost comparison for Phase 3.

2.1 Standalone WirelessHART network

The first phase of the pilot involved meticulous study of the entire sea water based desalination plant to identify possible field instruments to be included in the project and probable layout of the wireless mesh network to be established for optimum coverage and reliability. After taking site conditions, criticality of measurements, and various guidelines issued for designing WirelessHART networks into consideration, 15 instruments were included in the scope of pilot project.

Emerson Wireless Gateway1420 was erected on the roof of desalination plant control room. The wireless gateway along with a PC for monitoring were connected to a dedicated unmanaged ethernet switch through cat6 ethernet cable as shown in Fig1. All the associated tools like security setup utility etc were installed on the PC and wireless gateway was configured with IP address, Network Name and ID, Join Key and different user accounts for operation.

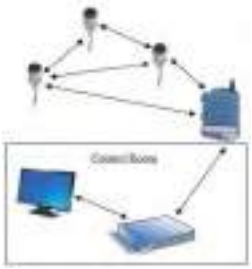

Fig 1

THUM adapters were initially installed directly on the transmitters utilising the factory cable available with the adapters.Handheld HART communicators were used to configure Network ID, 128-bit Join Keys and Burst Rate for all the 15 transmitters. The native web interface of the gateway was used to monitor the WirelessHART network as all the field instruments with THUM adapters automatically formed a self healing mesh network. It was also possible to form a network diagram and verify visibility of a node to the other nodes using the active neighbours feature.

PV, SV, TV and QV HART variables were monitored along with diagnostic and additional status data available on all the nodes in the network. However, it was observed that many nodes intermittently dropped from the network and the mesh would self heal subsequently. This was diagnosed to the poor signal to noise ratio (SNR) as a result of lot of metallic structures encountered within the line of sight of nodes.

To mitigate this, THUM adapters were relocated to a height of approximately 2 meters directly above the transmitter using an extension cable and a utility pole. The SNR improved dramatically and data availability through WirelessHART network also increased as the adapters were relocated to ensure lesser metallic obstructions within the line of sight.

2.2 Integration with Honeywell EPKS DCS

After the establishment of the standalone system with good network reliability, next phase involved integrating this system into the existing process control network. Since wireless network can be used as a threat vector by malicious users to gain access to the process control network, a firewall with appropriate policies was placed between the standalone system and process control network as shown in Fig 2.

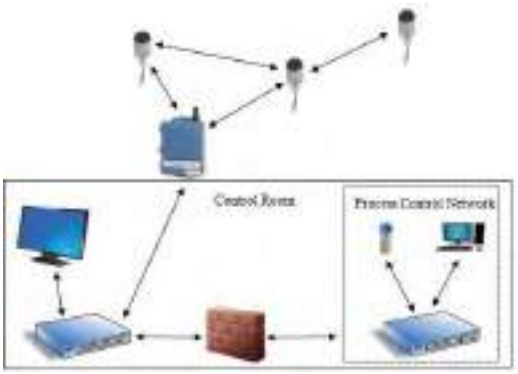

Fig 2

The communication was established on Modbus TCP/IP protocol by configuring suitable controllers and channels in Honeywell Quick Builder tool inside Honeywell EPKS DCS. **Emerson's Security setup utility installed on standalone PC acts as a data server and communicates with DCS.** Once the communication was established, individual points were created for all the data to be imported into DCS. The existing DCS's Human Machine Interface (HMI) was altered to suitably incorporate the additional data in popup's near individual field instrument displays. View of these popup's was

however only restricted to the maintenance engineers and technicians to prevent cluttering of the process mimic's used by operations team.

Advantages of the system could be clearly seen once it was integrated with the existing DCS. Integration not only resulted in increased user engagement but also faster troubleshooting. Following the successful integration, reduction in number of components was done to ensure easy maintenance and monitoring of the system. Accordingly the scheme was modified as shown in Fig 3. The Emerson security utility was installed on one of the utility PC's available within the control network. Marginal increase in process control network traffic was observed.

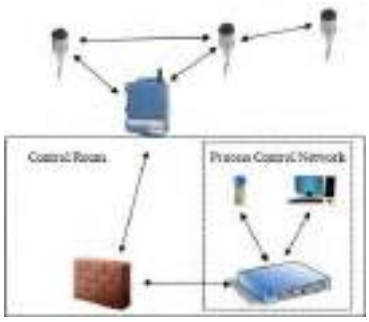

Fig 3

3. Use Cases

Few of the use cases wherein the additional data coming from WirelessHART network was put to use used for early diagnosis are described below:

3.1 pH Measurement

After implementation of the system, reference and glass impedance from Emerson's smart 1066 ph analyzers were brought into DCS and suitable alarms were implemented. Appropriate reference impedance values were decided and used to trigger maintenance activities. This marked shift from time based predictive maintenance to predictive maintenance regime resulting in significant reduction in man hours and extending gap between calibrations.

Low glass impedance alarm which indicated damaged or poisoned sensor was also used to quickly requisition and change the faulty pH sensor thus reducing downtime of the reading.

3.2 Conductivity Measurement

Input resistance values from Emerson's smart 1066 conductivity analyzers were logged as an additional variable in DCS and suitable low/high value alarms were configured. These alarms were

used multiple times to quickly diagnose and rectify loose cable connections or inadvertent cable shorts for ensuring maximum uptime of the values.

3.3 Pressure Measurement

Major diagnostic message bits available in Honeywell ST3000 pressure transmitters were configured in DCS. These messages were used to quickly identify and rectify faults like cable damaged (based on low supply voltage alarm) or instrument mode non-reversal after maintenance (based on operating as current source alarm).

3.4 Control Valve

Lot of diagnostic information bits available within Siemens Sipart PS2 valve positioners are not traditionally utilised. Monitoring this additional data made it easier and quicker to identify gland packing/valve sticking/jerky operation issues (based on deadband, stiction and dynamic behaviour exceeded alarms), air leakage (based on pneumatic leakage limit exceed) etc and could be attended much before there was major loss in process control due to control valve malfunction.

3.5 Level Measurement

Siemens Level transmitters installed at the top of tanks at site were directly exposed to sea water mist from nearby cooling towers and resulted in heavy corrosion of support structure of canopies. As the top of tanks are hazardous location and thus seldom accessed, frequent inspection of transmitter and canopy condition was difficult. Monitoring of electronics temperature along with other diagnostic information in DCS was a suitable alternative to knowing the health of field instrument. High temperature alarm was used to diagnose canopy damage (based on high temperature alarm) and foaming in the tank (based on loss of echo).

3.6 Acquiring Additional Process Data

There was new requirement from operations team to measure incoming sea water's temperature. Traditionally this would have meant the time consuming process of designing, procuring, installation and commissioning of thermowell, RTD sensor and temperature transmitter. However, using the WirelessHART network, the process temperature from already installed sensor measuring pH of incoming sea water was pushed into DCS. This was one among many examples where additional data was acquired at fraction of the cost and made available within a couple of days from requirement requisitioning.

4. Cost Savings

A brief exercise for phase 3 of the project was undertaken to compare cost implication for acquiring new process data through an instrument placed 1Km from the control room via the traditional wired and WirelessHART (completely wireless instrument) route. The details for are as shown in Table 1:

Table 1

Items	**Traditional wired setup cost (INR)**	**Wireless instrument in setup cost (INR)**
Instrumentation Cable (1Km)	58,285	Minimal for Lan Cable
Cable Laying (1Km)	3000	Minimal for Lan Cable
DCS AI card (Cost per point)	5906	Not applicable
Junction Box (1 Nos)	4900	Not applicable
Instrument (1 Nos)	X	1.2 X
Wireless Gateway (Cost per point)	-	2000
Battery (3 replacements at high update rate)	-	24000
Total	72091 + X	26000 + 1.2 X

Besides being extremely quick and convenient, adding truly wireless data points is easily viable for process data which is located farther from the control room due to additional costs incurred for wiring. There is scope to save up to 50-60% in costs (depending on site and configuration) and reduce time required by 90%.

5. Results and Conclusion

The results from the phase 1 and 2 of the project exceeded the requirements set out initially during the conceptualization of the project. There was saving of 15-20% maintenance man hours against the historically required man hours. There was increased employee engagement as less time was spent on preventive maintenance and employees were able to devote more time to value adding activities like taking up improvement tasks, diagnosing field instrument problems before failure etc.

There was cost saving and time reduction of up to 90% for many data points which were required to be added for process monitoring by utilising additional information available within existing instruments. There was no need to maintain separate compliance logs for calibration as all the results along with timestamp would be available in the DCS for further reporting.

For newly commissioned or mid life automation projects with no option to intrinsically acquire HART data from smart wired instruments already installed in the field, using wireless adapters (irrespective of whether they are part of WirelessHART or ISA100.11a) presents the best opportunity to bring diagnostic and additional data into the control systems. This would enable the asset owner to shift to a predictive maintenance regime, cutting costs and increasing productivity in the process.

Since all the instruments are hardwired, latency of the wireless communication would not be a major factor. Hence, both critical and non-critical measurements can be hooked up to the wireless network for data assimilation into existing control system. Also, few instruments may have to setup as router only nodes based on layout for optimum coverage and redundancy in communication paths. However, adequate precautions would need to be taken to secure communications between field devices and gateways to ensure no unauthorised access to connected process control network.

Conveyor Health Monitoring System based on Advancements in Photonics and Machine Learning

(Sumit Kumar Haldar, Gunjan Tandon, Praveen Kumar Gupta)

NTPC Ltd.

Abstract

Conveyors typically operate in demanding conditions, dirty environments with intense heat, high moisture and varying temperature regimes. A tricky maintenance problem for Material Handling maintenance personnel is detecting and replacing worn out rollers. Unscheduled conveyor stoppages can result in huge losses and can become a safety hazard responsible for sporadic fire related incidences especially in Coal Handling Plants.

Conventional methods of failure detection are time consuming, labour intensive and at times can be unreliable. Visual and auditory inspection is time-consuming, tiring and subjective and becomes virtually impossible during bad weather. This manual inspection leads to exposure to numerous safety concerns including occupational health and hygiene risks. Therefore it becomes imperative to make use of recent developments in the field of Science and Technology especially in Photonics, Machine Learning and Deep Learning to perform continuous monitoring of the health of conveyors, idlers, rollers and drive motors and extend Industry 4.0 in the Material Handling domain as well.

1. Introduction

In the early years of the last decade research in the field of Photonics led to the development of four different technologies for monitoring health of conveyors in Material Handling. These are as follows:

1. DAS (Distributed Acoustic Sensing Technology) being by FFT – Australia, HAWK – Australia, Fotech – UK and Bandweaver – UK.

2. DTS (Distributed Temperature Sensing Technology) being used by Yokogawa – Japan and Bandweaver – UK.

3. Hybrid technology incorporating DAS (Distributed Acoustic Sensing) and DSS (Distributed Strain Sensing) based Technology (developed by HAWK – Australia)

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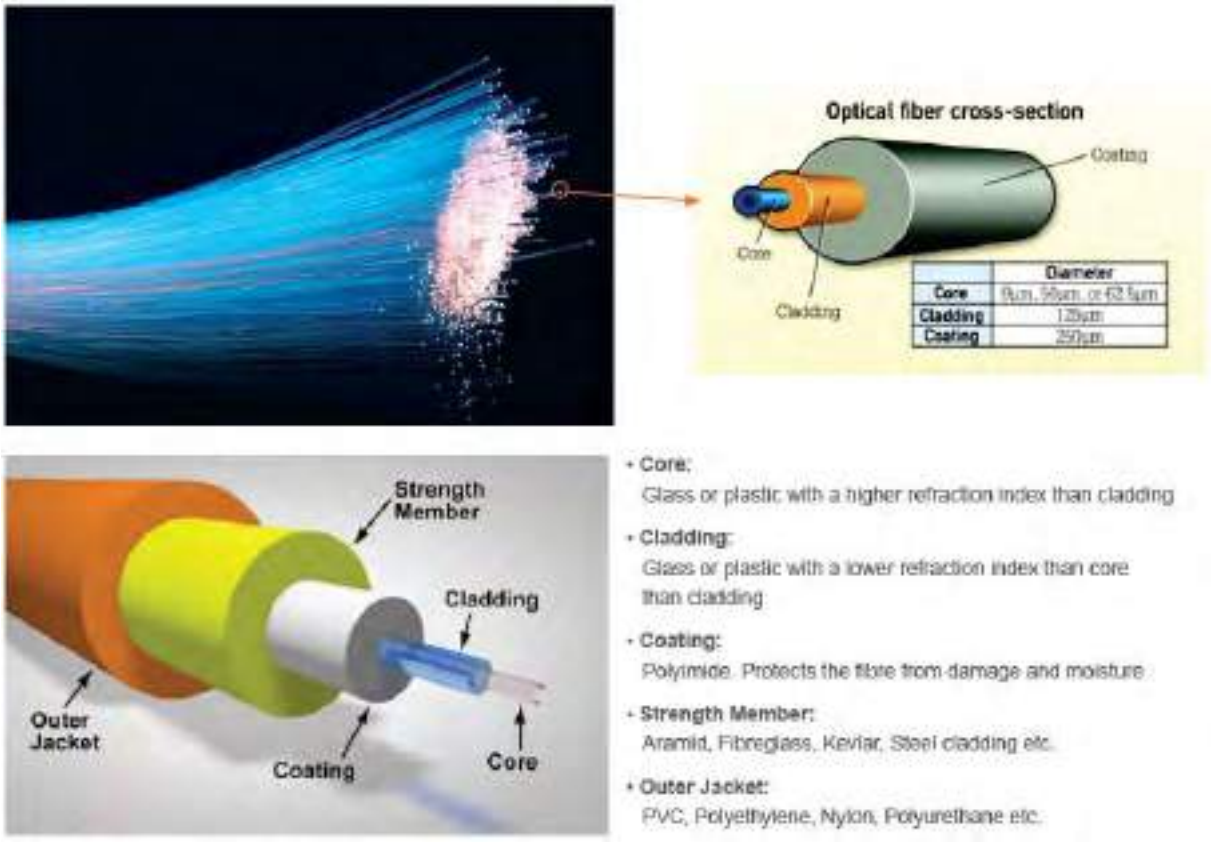
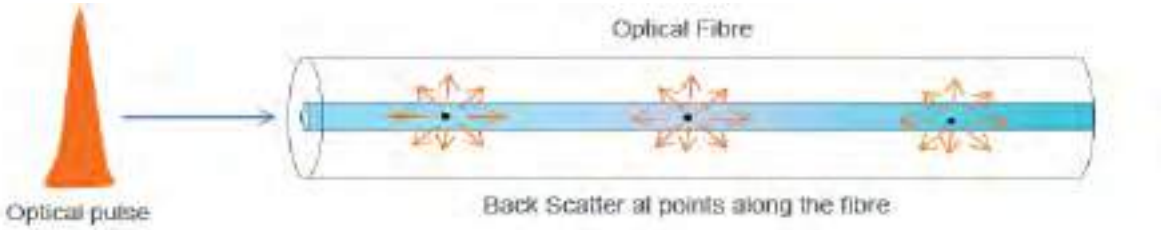
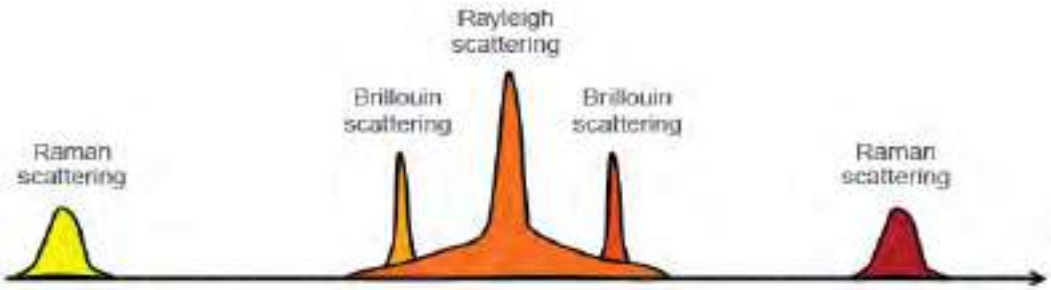
4. Concept of Smart Idlers (recently developed concept) being used by Vayeron – Australia.

The basic sensor in this kind of monitoring is single mode / multi-mode fiber optic cables. Single mode fiber optic cables are used in DAS and DSS technologies and multi-mode fiber optic cables are deployed in DTS technologies.

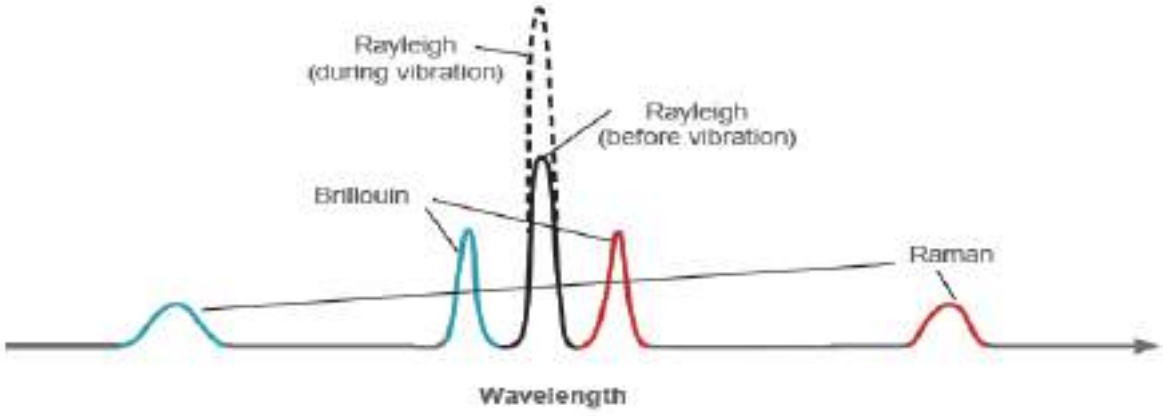


In order to understand how DAS / DTS / DSS operate, we need to understand the principle of Optical Back Scatter. When laser pulses are impinged from one end of the fiber, due to impurities in the construction of the fiber cable backscattering of incident laser pulses take place at various points. On observing and assessing the backscattered light and on performing spectrum analysis, three prominent scattering effects are observed namely Rayleigh scattering, Brillouin scattering and Raman scattering.

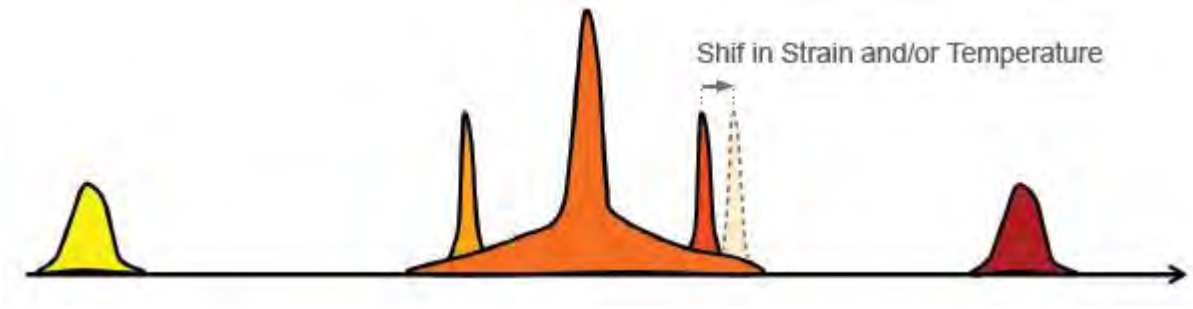




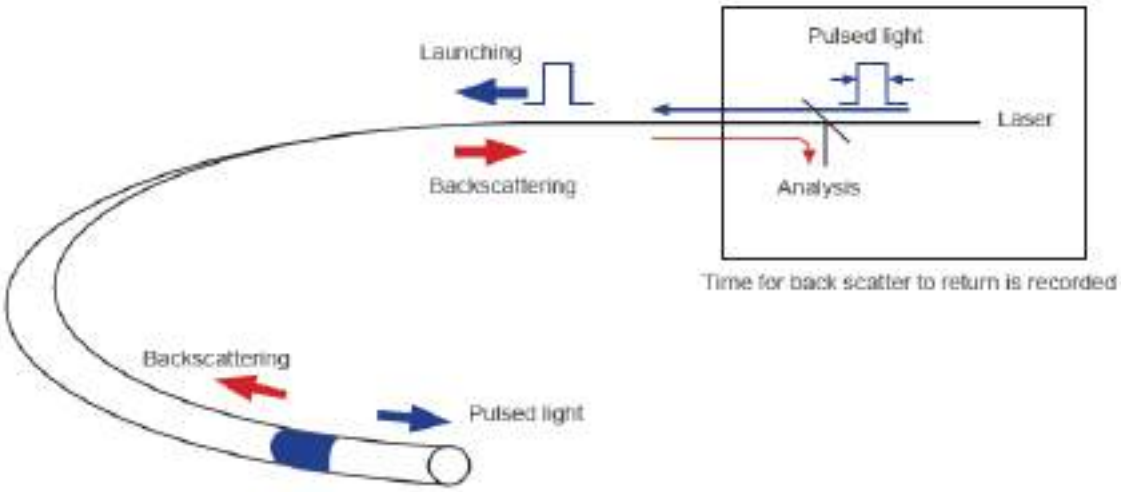
Rayleigh backscattering is prominent in case of Acoustic, Sound and Vibration signals near the fiber optic sensor. Increases and decreases in the in the Rayleigh component of the backscatter can be attributed to density variations due to vibration of the fibre. These changes in density variations can be measured and reported as Sound, Vibration or an Acoustic wave form.



Brillouin Scattering is prominent in case of Strain signals predominantly and in some cases for temperature signals. Brillouin Scattering varies due to changes in the reflective index within the fibre and is setup as a loop (2 cores within one cable). The increase or decrease in reflective index can be due to strain or temperature. Special techniques are used to separate the two to give independent readings for temperature and strain.



Along with sensing methodology, time of flight is crucial for fiber optic based sensing. Time of flight in the form of time for back scattering signal to return is recorded.



Locations of events are able to be accurately determined the time of flight method. Similar to radar, sonar and ultrasonic instruments, the amount of time from sending the laser pulse to receiving a return signal is recorded. Due to the internal properties of a fiber optic core, the speed of light through a fiber is consistent at approximately two thirds of the speed of light through a vacuum (around 400 microseconds for a 40 Kilometer round trip). As speed is consistent, the return time can be used to calculate a distance on the fiber down to as accurately as 250 mm.

3. Technology review for Conveyor Health Monitoring:

Distributed Acoustic Sensing Technology: DAS system is a tested and proven technology which makes use of FO cable as a sensor and measures the acoustic and vibration signals. The principle of operation is based on COTDR (Coherent Optical Domain Reflectometry) which in turn is based on the principle of Rayleigh backscattering. This system makes use of an advanced

fibre optic detection and sensing technology platform in combination with advanced signal processing algorithms and machine learning.

The unique system transmits a series of short laser pulses along a single fiber optic cable retrofitted along the length of a conveyor. When bearings wear, they vibrate. Vibrations travel through the conveyor's frame and onto the cable causing microscopic changes in the backscattered laser light. Data from these changes is simultaneously gathered from every meter of the conveyor and the controller associated with the device which includes the optical and electronic unit processes this data through various signal processing algorithms and alerts operators, on- or off site about potential failures. Typically these systems can detect a broken ball or cracked cage in a ball race, observe and track idler bearings as they wear and predict bearing seizures. The advanced signal processing and patented AI algorithms which are available with most vendors remove all the noise and interference and reveal just the diagnostic signals for the bearing conditions.

To summarize, DAS systems can proactively detect failure of idlers / bearings prior to increase in temperature / friction between moving parts i.e. all kinds of incipient failures based on the acoustic signature.

Distributed Temperature Sensor Technology: Optical fiber cables can be used as Temperature sensors. In this technology, laser pulse goes within a fiber scattering in all directions. The backscattered light generally contains three components a) Raleigh, b) Stokes and c) Anti-Stokes. Temperature is calculated from intensity ratio of stokes component and anti-stokes component. The location of the point of temperature rise can be calculated as product of Speed of light and Round trip time. In case of Conveyor belts, this technology has been successfully used by some vendors for indicating the location of fire at a conveyor.

Thus DTS system is suitable for fire detection when bearing is already at high temperature or ignition may have already commenced. DTS systems are primarily suitable for being used as a Safety system.

Hybrid technology incorporating DAS & DSS: Recent advancements in electronics and signal processing technologies have allowed solution providers to merge DAS and DSS technologies in a single controller enabling sensing of not just vibration or acoustic signals but also strain signals. This dual measurement technique has also allowed the same controller to be

used for rise in temperature and detection of chances of incipient fire incidences. At the same time the Interrogator is monitoring for vibration it will continuously hunt for temperature spikes along the belt's length. The main use of temperature in conveyor applications is for fire detection where an ignition has occurred. The controller / interrogator accomplishes this by scanning a separate fiber within the cable and looking for changes to another component of backscattered light called Brillouin refraction. The system can be calibrated to run very quickly (a few seconds) using lower accuracy (±1°C) scans of the fibre for temperature, or take a slower (30-60 seconds) more detailed scan for maximum accuracy (±0.25°C) of temperature to sense even the smallest changes.

Temperature as a primary sensing variable is not recommended as heat transfer from the bearing to the support and from the support to the fibre is minimal. Typically a temperature sensing fibre is connected to an overhead catenary wire that sits under the weather shield and monitors conveyor air temperature. In this way Distributed Temperature Sensing (DTS) can thereby be utilised for general fire protection duties of any linear infrastructure.

In normal conveyor belt configurations vibration acts as a primary sensing and detection variable used to schedule maintenance activities where temperature monitoring is used as an emergency condition detection method.

Concept of Smart – Idlers: This is a new concept developed by a firm named M/s. Vayeron. The components of this system comprised of the following:

Smart Idler® – an electronic module housed within a mechanical conveyor roller. The conveyor roller monitors the temperature, vibration and sound within the conveyor roller and communicates this data to the Gateway via a wireless network. The Smart-Idler® is powered directly from the rotation of the conveyor roller. Sub-components of the Smart-Idler® module are as follows:

1. Rotor – Internally coupled to the rotating conveyor roller bearing housing. The rotor is sized to follow the outside diameter dimensions of the bearings themselves.

2. Stator – Shaft-mounted component which contains the on-board data acquisition, analysis and radio electronics.

3. Antenna Cap – Protective cover to ensure that the Smart-Idler® antenna is not damaged in the field.

This technology is new and is being promoted by M/s. Vayeron, Australia. On reviewing the above technology options and based on interaction with various OEMs working on these technologies, it is observed that DAS based technology which can successfully identify various incipient faults based on acoustic signature from the idlers at an early stage is very suitable and has been utilized successfully by various vendors viz. M/s. FFT, M/s. HAWK, M/s. FOtech and M/s. Bandweaver at similar such applications worldwide. Further this technology has matured over a period of time and is being used extensively for many similar applications using acoustic signature to monitor pipeline leakages, intrusion detection, communication cable monitoring, smart cities etc.

Many vendors are providing central cloud based reporting and analytics platform which can connect wirelessly to the Edge servers associated with these systems thus ensuring availability of alerts and reports from conveyor assets located anywhere in the world are accessible on any internet – enabled device in near real time.

4. Primary Areas of Application:

Installation Locations:

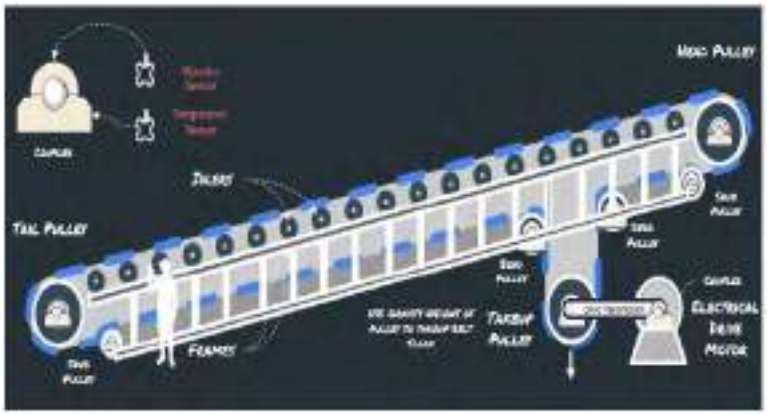
1. Coal Mines, Hazardous Area (No infield electronics)
2. Hard Rock Mines
3. Quarries
4. Buildings
5. Unmanned Material Handling Facilities
6. Processing Plant Conveyors

Possible Applications:

1. Overland Conveyors
2. Building Fire Detection
3. Conveyor Fire Detection
4. Remote or Rural Conveyors

5. IIoT Sensors for monitoring of Conveyor Motors and Pulleys:

Vibration patterns and temperature of Pulley couplers can be monitored by attaching vibration sensors on the top of transmission coupler housing and measuring X, Y and Z movement by using IIoT sensors. Similarly the surface temperature of the coupler housing can be monitored using IIoT sensors. Increase in temperature above set values indicate excessive friction in the bearings leading to their failures.



Pulley Installation

6. Analytics and Dashboarding:

The IIoT Network solutions and platform associated with these technologies provide a means to wirelessly connect one or more interrogator / controller units which also act as edge servers to a central cloud reporting and analytics platform. This enables alerts and reports from conveyor assets located anywhere in the world to be accessible on any internet enabled device in near real time with very limited efforts.

Conveyor Health Intelligence Platform would provide deeper insights to maintenance technicians, site personnel, regional operational hubs and global headquarters, conveyors are

automatically connected to the cloud via an Industrial Grade Wireless IIoT gateway, enabling daily asset reliability reports from every conveyor, at every site around the world.

The Analytics platform generally provides reports of various types:

1. Reports – Highlights locations that should be monitored or inspected based on their Overall Severity.
2. Heat Map – Lists the performance of all roller locations, their Overall Severity and individual feature values
3. Frequency Plots – Diagrams that plot the frequencies and their magnitudes at each location.

Supervised Machine learning algorithms are implemented to develop models which can predict the failure of idlers. The heatmap lists the performance at all locations, it's Overall Severity Level (OSL) and features that were included. Each feature mauy be rated from 0 to 7 then some are weighted based on their perceived severity. The OSL is the sum of the individual feature values.

1. Knocking & Squealing – Late stage failure symptoms
2. Rattling & Squeaking – Mid stage failure symptoms

3. Rumbling – Early stage wear symptom

7. Benefits of the system:

1. Traditional condition monitoring tools only collect and display readings.
2. Data analysis is manual and relies on experts to interpret results.
3. Smart wireless IIoT predictive maintenance solution allowing Condition Monitoring to become Health Monitoring (including Diagnostic / Prognostic).
4. Automatically collects data, identifies anomalies, classifies defects and tracks failure progression.
5. Alerts and smartly displays outcomes – providing deeper insights from a single platform accessible anywhere in the world via desktop, tablet or mobile.
6. Reduces unplanned downtime – anticipating issues before they occur.
7. Enables convenient roller change-out timing – ensuring viable rollers remain, while unviable rollers can be changed via a managed process.
8. Proactively detects and tracks bearing failure progression.
9. Intrinsically safe (suitable for use in hazardous areas and underground mining), immune to lightening, EMI (Electromagnetic Interference) and RFI (Radio Frequency Interference). No electrical current or in-field electronics.
10. Reduces exposure to safety risks by eliminating manual inspections and reducing manual maintenance.

8. Conclusions:

DAS based Conveyor health monitoring system is already in operation at various conveyor systems around the world viz. Australian port Rio-Tinto. These systems are being tried and tested in major ports, material handling plants of major Steel manufacturing firms, Coal mining firms for their conveyors which span over several kilometers. This technology along with Smart idlers and IIoT devices for condition monitoring of drives have potential for introducing

Industry 4.0 in areas like Material handling which have traditionally been highly labor intensive. Advances in the field of Machine learning and Artificial Intelligence has allowed us to obtain predictive information on incipient problems getting developed in idlers or rollers which are responsible for around 85% of the issues arising in Conveyor systems. As systems mature, better stability in the laser pulse is obtained and new advancements in the signal conditioning of the backscattered signals take place, the performance, accuracy and the distance of monitoring with the help of a single controller will improve further.

References:

1. Catalogues, Datasheets & manuals obtained from M/s. FFT.
2. Catalogues, Datasheets & manuals obtained from M/s. HAWK.
3. Catalogues, Datasheets & manuals obtained from M/s. FOtech.
4. Catalogues, Datasheets & manuals obtained from M/s. Bandweaver

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