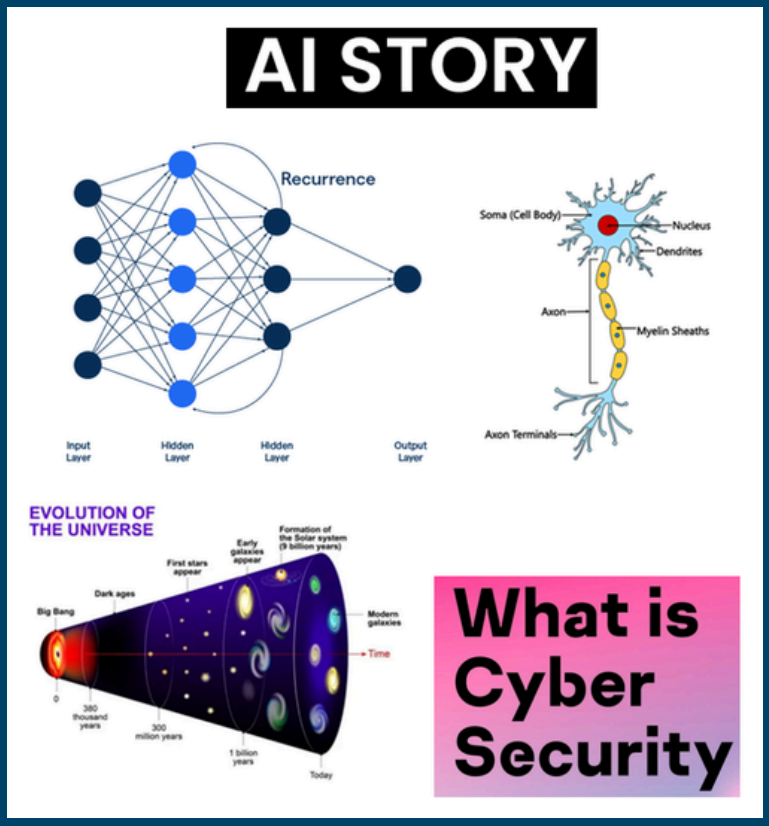
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INDIAN NUCLEAR SOCIETY

NEWSLETTER



CONTENTS

1. INS President's Message 1
2. From the Editor's Desk 3
3. The AI Story : How it got into shape 5
4. Cyber-Securing Control Systems of Critical Infrastructures 12
5. Gamma Ray Bursts : Shedding Light on the Cosmos 19
6. INS Round-up
@ Report of INS-sponsored Conference and Outreach Programme at ICFAI University, Tripura 27
@ Report on one-day workshop on "Societal Aspects of Nuclear Energy: From the Core to the Citizen" 30
@ Report on Public Awareness Programme on "The Role of Mass media in the success of Nuclear Energy Technology" 32
@ Report on TRAINING MODULE FOR BHEL OFFICERS ON NUCLEAR SCIENCE & TECHNOLOGY 36
@ Report on 80th Independence Day Celebration 42
@ Report on INS outreach programme at VIT Bhopal 19th August, 2026 43
7. Snippets 45

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President's Message

Dear INS Members,

On 14th August 2026, the Department of Atomic Energy and the Atomic Energy Regulatory Board released, for public comment the long awaited draft of rules and regulations. The rules govern who may hold a nuclear licence and on what terms; the regulations govern the question of the safety authorisation process by which the Board permits a licensee to actually site, construct, commission, operate and eventually decommission a facility. It paves the way for the effective implementation of the SHANTI Act. passed by Indian Parliament in December, 2025 to facilitate the participation of private-public sector looking forward to join the national nuclear mission.

SMRs have finally arrived! The first BWRX-300 unit is currently under construction in Canada, the first of four of the SMRs planned at the Darlington New Nuclear Project site. The US Nuclear Regulatory Commission has issued a construction permit for the Tennessee Valley Authority's planned GE Vernova Hitachi BWRX- 300 small modular reactor at the Clinch River site last week. It paves the way for the nation's first commercial small modular reactor. There are also projects advancing for fleet deployment of BWRX-300 units in Poland and the UK.

At home too, the Bhabha Atomic Research Centre (BARC) has initiated discussion with India's largest energy and engineering companies like Reliance Industries, Adani Group, Larsen & Toubro and NTPC regarding the indigenous 300-megawatt (MW) Bharat Small Modular Reactor (B-SMR-300}, which has a targeted capital expenditure of Rs 30 crore per MW. The plan is to establish an industry-backed special purpose vehicle (SPV) that will hold the intellectual property (IP) rights.

Dear Friends, we have completed 5 quarters of present EC and have only nine months left to rededicate ourselves for the tasks ahead and meet the aspirations of our honorable members. I have great pleasure in informing you that in response to your desire, membership certificate is available on our website viz. ins-india.org and it can be downloaded after log in. I understand many of you have already received their certificates this way. In case, you have an issue, please write to indiannuclearsociety@gmail.com with your particulars like name, email, contact no etc. We will be too happy to help you out. Your society has requested all members to submit a Google form with personal details for preparing their identity cards which will be delivered to your address. Though response has been good but we urge every member to submit form and avail this facility.

Friends, it gives me immense pleasure to inform you that INS has initiated Training program on nuclear science and technology for the officers of a Maharatna PSU , Bharat Heavy Electricals. Faculty was carefully selected based on the feedback received through Google form sent to all INS members. While, I am writing this note, course on Nuclear Reactor Materials is in progress at HRDI, BHEL, Noida. Course content and the faculty received accolades from the officer trainees as well as BHEL management. I would like to express my sincere gratitude to the faculty members for supporting INS in this very important activity which is particularly relevant in the context of national nuclear mission.

INS organised outreach programs in August, 2026 in Bhopal at three prestigious academic Institutes viz. Maulana Azad National Institute of Technology (MANIT), Vellore Institute of Technology (VIT) and Makhan Lal Chaturvedi National University. Response of participants was overwhelming and the coverage in media was remarkable. I would like to thank the INS team of resource persons and the coordinators of the host institutes for their sincere efforts.

Independence Day was celebrated with customary patriotic fervour jointly with AERWA. Prof. U. Kamachi Mudali, VC, HBNI addressed the gathering as the Chief Guest. National song as well as national anthem were recited on this occasion.

INS, Hyderabad Chapter is organising an international symposium on critical minerals and materials as elements of change : A global perspective along with AMD from 8th-10th October, 2026. INS-HQ extends the best wishes for the success of the symposium.

Dear Members, you may have received the announcement of Annual Conference of your society scheduled on 29th-31st October, 2026. This time, the venue is an academic institute, HSNC, Worli and we hope that it will help in spreading the message, “Nuclear Energy and Nuclear Radiation: A Boon to the Mankind” to various sections of society more effectively. I urge members to register in large number and avail the opportunity to interact with who is who of nuclear industry in the meeting. We are fortunate that Homi Bhabha's Birth Day falls during the conference. It is proposed to organise the celebrations with the delegates and other special invitees.

I would like to once again request members to visit INS website www.ins-india.org regularly and share with us their perspective of our activities to achieve the objectives of INS and the possibility of their contribution in the area of their choice. We are always keenly looking forward to their advice and believe that together we can enable the society to meet the aspirations of nuclear community at large. Finally , I would like to thank the Editor and the Board members for their painstaking efforts to compile and publish the Newsletter at regular intervals.

Jai Hind
Dr. Vijay Manchanda
President, INS

From Editor's Desk

Dear members,

The editorial team is happy to bring forward this 4th newsletter after the new EC team of INS took over. It has been an exciting time looking around to identify contemporary topics of general interest to members. For many of us, the current technologies that we see around like, application of artificial intelligence, growth of digital media, ease of digital life certificate for yearly renewal to get uninterrupted pension, cashless transaction, video conferencing, growing benefits of nuclear medicine, etc. have entered our lives seamlessly as if we have grown with the development. For this quarter we have chosen 3 contemporary articles viz, Cyber security, story of AI and big bang hypothesis to explain the cosmos as space scientists try to comprehend.

First on cyber security. Claude Mythos is a frontier artificial intelligence model that has advanced skills in finding and fixing software security flaws. It can find hidden, dangerous bugs in very old software code much faster than most humans can. Nuclear industry has witnessed a huge leap in computerisation and automation in the last two decades (e.g. smart grids). This article aims to throw light on the security in industrial infrastructures: its historic evolution, international & national initiatives, and methods of securing control systems including that of nuclear power plants. It also deals with measures to protect industrial systems from cyber-attacks by security-by-design concept, risk-informed life-cycle security models and deployment and maintenance of relevant security controls.

Second on Cosmos. The Big Bang theory is the leading scientific explanation for how the universe began as an extremely hot, dense point about 13.8 billion years ago and expanded outward. As space stretched, it cooled down, allowing basic subatomic particles to form. The hypothesis is primarily based on the four key observational milestones; the expansion of the universe, nucleo-synthesis, cosmic microwave background radiation, and large scale structure formation. The presence of Hydrogen and helium, throughout the universe, also supports the Big Bang hypothesis. These elements (75% hydrogen and 25% helium) are predicted to have been created during the Big Bang via nucleo-synthesis. The article talks about the Gamma Ray Bursts (GRBs) ; considered as monsters of the universe, that occurred after Big Bang .

The third on AI. Using advanced machine learning algorithms trained on vast libraries of literature, AI can analyze storyline structures, predict narrative patterns, and generate complex text in a matter of seconds. AI serves as a powerful new medium in the history of narrative, transforming how stories are conceived, written, and consumed. AI is in everything. It is the God of this digital era. Looking for AI assistance is so common these days - be it for planning a travel itinerary, to understand a medical condition and seek remedial options, to find a solution to a technical problem. The article narrates how AI got into shape by training, learning the basic language, grammar, world facts and reasoning. For this it undergoes a self-supervised learning using data from websites, books, scientific papers and even from code repositories. After the basic model is developed, it has to learn how to behave like an assistant, follow user's instructions and format replies. The AI systems these days accept all forms of inputs image, video, audio, graph, chart etc.

In this quarter INS successfully carried outreach programs in universities colleges and schools. The feedback and follow up actions has encouraged INS to undertake innovative programmes for general public especially on the ever increasing benefits of nuclear radiation.

Currently, INS is gearing up to organise its annual conference (INSAC-2026) jointly with HSNC University Mumbai. Members are requested to visit INS website (www.ins-india.org) and www.insac2026.org for information on registration, sponsor, abstract submission and many more. As always INS request members to suggest good programmes focused on nuclear science and engineering that can benefit professionals in various fields, industry, MSME, colleges and universities. I thank the editorial board members of the INS Newsletter who have supported in bringing the newsletter of this quarter.

Jai Hind
Dr A Rama Rao
Member, INS



A Tribute to Dr. Homi Jehangir Bhabha – Father of India's Nuclear Programme

The AI Story : How it got into shape

Prabir Pal, Ex-DRHR, BARC

A few months ago I was struggling with the zoom lens of my camera. It refused to focus. I thought let me just take chances and ask for suggestions from Gemini, Google's AI app. And there it explained to me beautifully how because of long non-use, the lenses may have developed stiction and is thus resisting motion. It advised me to manually move the lenses a number of times to and fro and try, and the trick really worked. How easily I got an expert's advice!

AI is the buzzword now. It's in everything. It is the God of this digital era. Looking for AI assistance is so common these days - be it for planning a travel itinerary, to understand a medical condition and seek remedial options, to find a solution to a technical problem, it never fails to come up with excellent explanations and suggestions. I wonder how it understands the questions so precisely and gather relevant informations to put them down so nicely for me to understand and act! I started writing this article to explore and explain this wonderful journey of AI from a layman's point of view.

We have also been hearing about the exploits of AI. The popular view of AI at the moment is negative. It is likely to remove large chunks of blue-collar jobs, it is misused to deceive, defame and even kill people at the warfront. Yes, these are all real dangers, and the AI system developers are trying to bring in some guardrails in their framework to protect against some of these misuses, but to what extent they succeed has to be seen. In the present article of course I shall leave them aside and focus only on tracing the evolution of AI to its present form. Technologies evolve because the human mind is curious and creative. They evolve irrespective of their cosequences – good or bad.

What is AI?

We had electronic calculators in our college days to simplify large computations, and then came computer programs – a sequence of logic driven instructions which the computer painstakingly follows. What is so special about AI that it is differentiated from these programs? A naïve and short way of answering this question is that those computer programs were designed by human minds, but we wished to build a system of programs that solves any well specified and solvable problem without being instructed on how to do that, and that is AI. But AI is much more than that. Humans have these special abilities that they can talk to and listen to others, they can recognize and understand their environments through touch and vision, and they can even control their environment through application of force. Realising these abilities on machines have been a major part of AI too.

The beginning

After the advent of electronic computing machines, it was Allan Turing who first thought in 1950 about the possibility of realising intelligence on a computing machine. He even prescribed a way of testing whether a machine is truly intelligent or not by checking if a human judge can differentiate between a coversation (through keyboards and monitors) with a person and a conversation with a machine. This famous 'Turing test' has been quite notorious to clear for AI systems, and it was only in the last decade that the Turing Test was finally cleared.

In 1956, some of the great minds came together in the Dartmouth Workshop and discussed possible approaches to realise intelligence on machines, and the term Artificial Intelligence was coined. The first functional AI program of Newell and Simon was presented around this time.

They advocated the use of problem specific rules to be applied systematically or heuristically (based on an intuitive principle) on the initial state of the problem to generate a tree of possible states through which one can search for the solution state. This was demonstrated to solve High School Geometry problems. They thought that the core principles of intelligence and learning can be encoded into a program to enable it to solve all kinds of problems. But soon everybody realised that real life problems also required a lot of knowledge to solve. Thus came the expert systems in the 80s, that used thousands of 'if then' rules to capture the knowledge of an expert. They worked reasonably well for some problems, but they were difficult to build, maintain and update.

In order to behave intelligently, a computer must recognise the objects and their locations in its environment by interpreting the digital image data from a camera. This is called Computer Vision. The traditional approach was to detect lines in the images, and infer their geometry from the way the lines meet each other, often by consulting a database of standard geometrical objects. Irregular shapes were difficult to detect. Shading and occlusions made the task even more difficult. Similarly, in speech processing (computer must understand what we say), the core philosophy was to break speech down into small manageable units and use probabilistic math to guess what was being said. None of these came to a level where they can be used in daily life.

In trying to understand and generate text, so called Natural Language Processing (NLP), the computer learnt exhaustively all the grammar rules only to fail here and there with real life textual information, because some more rules need to be added, or more often because real life communications do not always conform to rigid grammatical rules. In all these, attempts were made to devise mechanisms of intelligence specific to the class of problems.

They need to be continuously updated with additional rules. There is no element of learning. These are in sharp contrast to the intelligence displayed by living beings.

The Neurons

Human intelligence, or for that matter the intelligence displayed by many living beings, have their origin in the neurons in their brains. A neuron is a signal processing unit in the brain. It receives input signals from other neurons through its dendrites and outputs signals through axons to other connected neurons (see Figure 1). On receiving input signals, a neuron may or may not get fired, depending on the strengths of its input signals and its threshold for firing. If it gets fired, it outputs signals which in turn may fire other neurons. This is how sensory perception keeps firing neurons in our brains causing experiences, thoughts and actions. Not tens or hundreds, the human brain has about 86 billion neurons. These in turn are connected to each other in about 100 trillion ways. These interconnections are not fixed. They are in a continuous flux depending on our sensory experiences. These collections of Neurons with their dynamic interconnections have learned to identify patterns in the sensory signals, interpret them, and gather an impression about a situation or environment. It also triggers decisions for any actions to be taken so that the appropriate neurons can be activated to signal the related muscles.

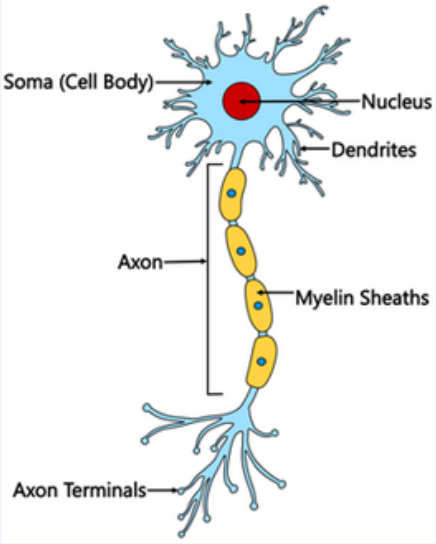


Figure 1 : A neuron with its dendrites to receive inputs and axon terminals to transmit outputs. The Myelin sheaths act as insulators to prevent leakage of signals through the axon.

Artificial Neural Network (ANN)

It was only natural to emulate the neurons of our brains to try to build Artificial Intelligence. An artificial neuron is a simple information processing unit which receives weighted inputs from some neurons and produce an output that propagates as inputs to some other neurons. The configuration of interconnections between the neurons and their weights would determine the behaviour of the Artificial Neural Network as a whole. Various functionalities emerged, but the one that sustained is a layered architecture of neurons that could learn to map a function from certain inputs to some desired outputs. For example, from the pixels of an image as input signals, a neural network may output the location of an object of interest (a human being / a car / a character) if present. Most of our intelligent behaviours constitute activation of many of such intelligent functions.

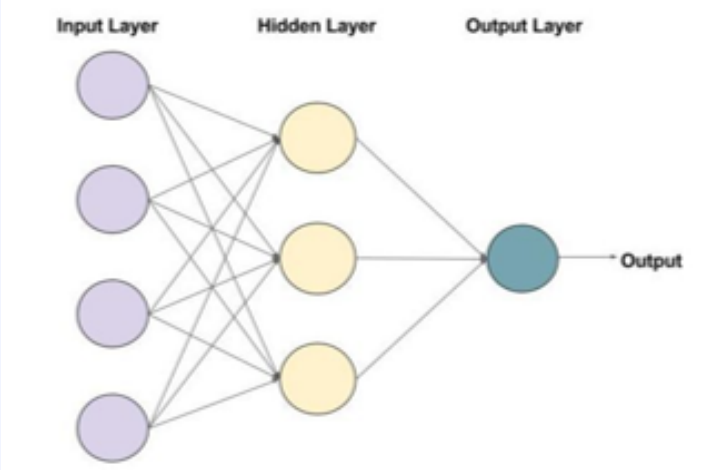


Figure 2 : A small illustrative feedforward neural network with only one hidden layer.

Feed-forward Neural Network

A layered architecture of neurons means there will be a layer of neurons to receive the inputs, a layer of neurons that will serve as outputs, and in between these two layers lie a number of hidden layers of neurons. Each neuron of a layer is connected to each neuron of a neighbouring layer through certain weights to regulate the strengths of the signals flowing through see Figure 2).

Since the signals always flow from the input layer to the output layer, these networks are also called Feed-forward Neural Network. The training of such a network to emulate an intelligent function takes place through the presentation of a large number of input-output example pairs (Supervised Learning) to the network while the training (Back-propagation) algorithm adjusts the weights of interconnections of neurons between the different layers to minimise the error between the expected and actual outputs. Once the network gets trained, it outputs sensibly to any inputs. The number of hidden layers were limited though, as it proved impossible to train a network of many layers because of a vanishing gradient problem. This in a way limited the complexity of input-output relations that could be learnt by such a network.

Deep Learning

In order to capture complex and abstract input output relationships, it is desirable to add more and more hidden layers to the network, but the training algorithms proved inadequate to train such a network. The processing function of an artificial neuron, known as the activation function, had so far been such that successive differentiations would flatten the signal resulting in no corrections to weights down the layers through back-propagation. This was now replaced by an activation function whose derivative is either 0 or 1, so the corrections flow through the layers unimpeded. To prevent overflow through multiplications, gradients are clipped to a hard ceiling.

Deep networks can be very deep (a few hundred is not uncommon) and can have many weights of interconnections (even billions). They need large amount of data to train. To prevent overfitting of training data resulting in memorization (remembering the facts) rather than generalisation (discover the guiding relationship), randomly some neurons are turned off so that the network does not depend too heavily on a single pathway.

Pre-trained layers are sometimes stacked to build and train a new network quickly. For example, a network trained to classify car models from images can be lifted and used to quickly train a network to classify birds from images. The lower and middle layers are used as it is and kept frozen during initial training, while the upper few layers that build the outputs, are trained with the bird images. At the end of course the entire network can be trained with a very low learning rate for fine tuning.

Many of the networks that we present below are deep neural networks with the capacity to capture complex input-output relationships through training with large datasets and to benefit through the use of pre-trained blocks wherever possible.

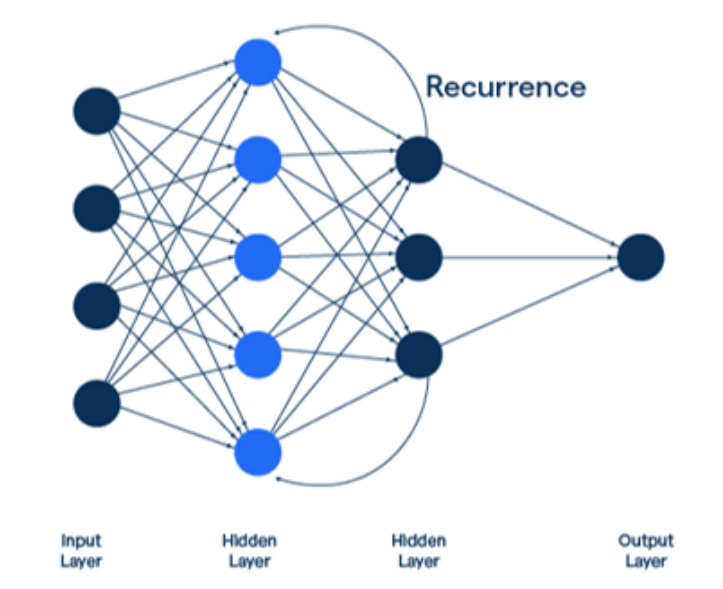


Figure 3 : An illustratative Recurrent Neural Network, in which the output of the last hidden layer is being fed back to the first hidden layer for computation in the next time-step

Recurrent Neural Network (RNN)

In cases where the output depends not just on the present input, but also on previous inputs, as in speech or text, which comprise a sequence of words obeying grammar rules, we use a sequence processing network.

As we present each word of a sequence to the input of this network, we expect it to output the most probable next word. This network is also layered, but a part of its output (or signals from the hidden layer just before the output layer) after processing the previous input word, is redirected to form part of the input to the network along with the current input word. That is how the context gets encapsulated into the input. Because of this feedback loop in information processing, it is called a Recurrent Neural Network (RNN). Such a network learns to relate a word to its predecessors in a sentence. So once trained with a large number of examples in which the next word is always set as the desired output, it learns to predict the most relevant next word in the text. This is how AI generates flawless text. The same principle holds for generating a video too.

Long Short Term Memory (LSTM)

The RNN always carries an extract of the previous words in its input to guide it to predict the next word, but in a long sentence the old words are easily weighed down by more recent words, so often some crucial clues get missed in the process. The LSTM proposes an architecture in which the network learns to carry forward important words in its context component and forget selectively the less important ones. But how does it know which one matters and which does not? Just as we know through experience, the network learns these parameters on the go. This enabled LSTM to respond sensibly to long sentence inputs.

Sequence to Sequence (Seq2Seq) Generation

Predicting the next word of a sentence in itself is not of much use. What we want is a machine translation of a sentence, the summary of a paragraph, answer to a query, or a simple conversation. These are all examples of a sequence of words available as input by the user, while we expect another sequence of words as output by the AI system. These sequences may be very much different in length.

Translation may not result in the same number of words, but they must be close by. Summary will result in a short output sequence in response to a much longer input sequence. In the case of a query however, the output may be very long even for a short query.

The architecture that enables such sequence to sequence generation has an Encoder to receive the input and convert it into a context vector – a compact representation of the input sequence, which is then fed to a Decoder that generates the desired output sequence. Both the encoder and the decoder can be RNNs or LSTMs. For the Encoder, the context vector can typically be the content of the uppermost hidden layer after the entire input sequence is processed. For the Decoder, the context vector fed by the Encoder along with the current state of the decoder (the state of its uppermost hidden layer) form the input for generating the next word. The decoder keeps outputing words in an autoregressive manner, always concatenating the context vector with the current state of the decoder as the input, until the end is sensed or encountered.

The Encoder-Decoder structure needs to be trained with large datasets which serve as examples. During training, it is only the decoder which receives the error feedback, which in turn flows into the Encoder for incremental corrections of its weights. In the early days, separate modules of encoder-decoder pairs were trained to translate, to answer queries, or to summarise a paragraph. But now-a-days the same encoder-decoder pair does everything because it is large enough to serve as all three and the knowledge that is common to all these modules gets shared in the process.

Attention Mechanism

It was felt that the nuances of an input sequence get missed in the process of building a fixed length context vector by the encoder.

More so when the input sequence is long. To get rid of this shortcoming, the attention mechanism evolved. In this, the hidden states corresponding to each word of the input sequence are consulted to determine how well they are aligned with the current state of the decoder. Accordingly they are weighted and summed up to form the context vector for decoding purpose. Thus the context vector is dynamically computed before outputing each word depending on the current state of decoding. This resulted in an output that is sensitive to each word of the input sequence.

Self-Attention and the Transformer Architecture

Although the attention mechanism solved the Seq2Seq problem quite nicely, there were practical difficulties in getting such models trained with a huge dataset (e.g., a trillion words), as the processes in both the encoder and the decoder were sequential in nature because of the feedback loops, which made these computations impossible to parallelise. Self-attention was designed to avoid this bottleneck by removing the recurrent loop altogether from both encoder and decoder, while ensuring that the goodies of the attention mechanism are not lost.

In self-attention, a sequence looks at itself to compute its representation in one go without going into recurrence. It essentially evaluates the relevance of each word with respect to others in the sequence. This is exploited in an architecture popularly known as The Transformer Architecture. It has indeed transformed the AI scene by making it possible to train the models with huge datasets on thousands of GPUs (Graphic Processor Units) simultaneously. The training that would have taken a lifetime now gets over in days.

In the Transformer architecture, both the encoder and the decoder are feed-forward neural networks.

While the encoder computes the representation of the input sequence using self-attention, the decoder computes a representation of the words it has already generated using self-attention. This is used along with the input sequence representation from the encoder to generate the next word. This operation is known as Cross-Attention. The decoder outputs one word at a time following the above cycle of operations.

Sizes of AI Systems

For AI systems, 'the bigger the better' rule holds. Size can be measured by the number of adjustable parameters (weights of interconnections of neurons) it has. In a way that determines its capacity to learn, and as it grows beyond a point, it is seen that the system starts showing emergent behaviour, i.e., it keeps evolving on its own, showing behaviour that was not explicitly built into it. There are models of various sizes - 1 to 10 Billions for mobiles, 30B-90B for private enterprise level deployment, and systems approaching 1 Trillion, like GPT-5, Claude 4, Gemini 3 etc. for wider usage.

Training

Training of an AI system proceeds in several stages. First, it has to learn the basic language, grammar, world facts and reasoning. For this it undergoes a self-supervised learning using data from websites, books, scientific papers and even code repositories. This is called Pre-training. Although the system acquires a vast amount of knowledge through this process, it is still dumb in the sense that it hasn't learnt yet to interact with the user.

After the basic model is developed, it has to learn how to behave like an assistant, follow user's instructions and format replies. For this it uses tens of thousands of high quality, human curated instruction and response pairs. It learns to recognise the purpose of an interaction – a machine translation, prepare a summary, or answer a query. At this stage, the system becomes capable of conversation with an user.

The last but a significant stage for an AI system is to learn what kind of response is aligned with human values, safety concerns and style of presentation. These are received quite often through human feedback. This is how the AI systems appear so friendly to us.

Multimodal Operations

The AI systems these days accept all forms of inputs – image, video, audio, graph, chart etc., apart from text. But the Large Language Models (LLMs) we have talked about can handle only text streams. So how are these diverse forms of inputs managed?

There are Modality Encoders, which employ pre-trained neural networks to process non-text inputs. For example, a Vision Transformer slices an image into a grid of patches, converting visual features into dense vectors. These are then fed into a connecting layer, called a Bridge, which mathematically projects the visual or audio vectors into a form acceptable to the LLM. Finally the LLM treats all these inputs at the same level, learning to interpret them and generate a sensible response.

While training, the model is fed millions of raw images, each paired with a short caption describing the image. Initially the Vision Encoder and the LLM module is kept frozen and only the weights of the modality interface (the Bridge) gets updated. Once the bridge starts translating effectively, the entire network is thrown into further training for fine-tuning.

Agentic AI

Instead of only answering queries, AI is now ready to act as an agent, trying to solve real-life tasks with minimal human intervention. At the core of an agentic system lies a LLM. However, this one is trained to interpret the user intent and depending on the nature of the goal, reasons and acts, observes the outcome and make corrections or fresh moves until the goal is achieved. Whenever necessary, it uses external software tools, functions, schemas etc to execute sub-tasks on the way.

It keeps a log of its plans and reasoning, examines them periodically and tries to correct itself if anything goes wrong. All these capabilities are acquired through extensive training of LLM models with highly specialised synthetic datasets containing logs of idealized agentic workflows.

Uses

AI finds uses in almost everything. In Healthcare (medical diagnostics) and Life Sciences (drug design), in Software Engineering (autonomous coding and testing, document processing, Cybersecurity (behaviour tracking), Smart Manufacturing (predictive maintenance), Logistics (demand sensing and route optimization), Finance (Fraud alerts, Algorithmic high frequency trading, personalised wealth management), Transportation (autonomous vehicles, E-commerce (user targeted recommendations, dynamic pricing model) etc.

How does one use AI in her daily life? A dashboard listing the current prices of all her financial assets and prospective investments. One uses AI for monitoring expenses, to evolve credit card usage strategy aimed at higher rewards, for trip planning, weakly meal planning, daily news briefing, emails through an aggregator, personal styling (how she would look in a particular dress or how dresses of different colours will look on her), how different hair styles will look on her, etc.

It goes without saying that one doesn't have to do a Google search any more. Ask anything and everything to the AI system. Where on the earth would you find someone who would answer all your queries – mundane or specialised - with equal ease and seriousness at any time of the day?

The Future?

There will be a clear shift from texts to action. Agents will gradually gain in strength and solve all kinds of complex problems of the real world. Multimodal operations will be ingrained in the AI systems. That would enable them to understand the context exactly like a human does, by reading facial expressions, hearing vocal inflexions, and analysing physical environments in real time. Robots will be more adaptive, capable of working in unstructured environments, in agriculture and even in household assistance. As more and more jobs get automated, complex jobs will still require human control with AI assistance. In order to be useful, humans will have to learn to work with AI tools. But will AI eventually achieve human cognitive capabilities across the board? It looks quite plausible. Although that doesn't mean that these systems will have consciousness as we do. That difference will stay unless meanwhile we are able to figure out how consciousness functions in the neurons of our brain and build artificial consciousness on silicon chips.

Cyber-Securing Control Systems of Critical Infrastructures

R.M. Suresh babu, Former Director Health, Safety & Environment Group, BARC

Anthropic's Mythos has rattled the digital world, and cyber security experts are scurrying to save their digital assets. Wars are increasingly being fought in the digital domain, such as Ukraine power grid blackout by a targeted cyber-attack, near-total internet and communication blackout in Iran, etc. When such a cyber-attack take place on Critical Infrastructure - power, finance, water, transport, communication, etc. – it affects an entire region or an entire country. Such attacks could become crippling during a war. Hence, we need to review how we secure our Critical Infrastructures from cyber-attacks.

Some of these Critical Infrastructures – such as power plants – has two major partitions of their digital assets: IT infrastructure and Industrial Control System (ICS) infrastructure. IT infrastructure by its nature is fully digital, while ICS infrastructure - although not fully digital in some domains such as Nuclear – has witnessed a huge leap in computerisation and automation in the last two decades (e.g. smart grids). Unauthorised and malicious modification of these systems (in software or hardware) or disruption of its functions can significantly affect the facility's operation. It may affect the safety (if safety functions are affected) or normal operation/availability (if control functions are affected) or it can lead to mal-operation by the operator (if control room functions are affected). Such malfunctions can also lead to accidents. While most discussions in the public domain focus on securing the IT infrastructure of Critical Infrastructures, much less is being talked about securing the other digital partition. Over the past two decades there is significant increase in cyber-attack on the Critical Infrastructure ICS, causing power back-out, communication blackout, urban water/sewage disruptions, etc.

This article aims to throw light on the ICS Security: its historic evolution, international initiatives, national initiatives, and methods of securing ICS of Critical Infrastructures, including that of nuclear power plants. But before jumping into the main topic, it is necessary to understand how ICS security is fundamentally different from IT security.

1.IT Security and ICS Security (ICSS)

When this author started working on ICS security in Department of Atomic Energy (DAE) there was not much awareness about ICS security and how it differs from IT security. People thought it is one and the same, and it was a daunting task to convince the people at higher echelons that these two domains require different approaches although there is some overlap between these in implementation.

The fundamental difference between IT security and ICSS is the resources at the disposal of the computing platform [1]. IT systems are typically connected – directly or indirectly - to office network and/or to internet and has considerable computing resources. This enables it to execute continuously programs in the background and look for malicious entities or activities based on latest malware-signature database downloaded from internet or from locally stored repository. A typical ICS has very limited computing power (sufficient to execute critical safety or control tasks) and is usually not connected to office network or internet. This renders ICS systems unable to continuously scan for malware and it is impossible to use the latest malware-signatures due to its isolation from external network. Other techniques such as intrusion detection would require additional computing resources.

Even if a safety system's computer is powerful, in some sectors such as Nuclear, the regulatory requirement prohibits execution of any function other than the safety functions on these computers.

Second difference between IT security and ICSS is in the software update cycle time. IT systems can update the software and malware-signatures at the earliest when these become available. In case of ICS, any change in software would have to go through a long cycle of verification and testing before the updated software is deployed in an operating facility, because any glitch in the updated software can significantly affect the facility operation. A few years back, a spacecraft mishap happened because of version control issue. In case of nuclear facilities even a change in one bit of the software has to go through regulatory oversight, which might take months before the updated software is deployed. Similar might be case in Space and Avionic sectors. This renders the protection against the highly organic and fast-changing malware landscape ineffective if not useless. In short, ICS software – mostly embedded software - should be thought of as deploy-and-forget type; it would have all vulnerabilities for years of operation as it would have at the time of deployment.

The above discussion leads to the fact that ICS should use security-by-design concept [1]. All the necessary security features - based on the operating environment and risk analysis – need to be planned, implemented and tested during ICS development process. Security features coming as after-thoughts are futile or would be infeasible to implement in ICS in a short time. In other words, while IT security is mostly reactive, ICS security must be proactive.

2. History of Cyber-attacks on ICS

The first ever recorded cyber-attack on ICS took place in early 1980's in Soviet Union that compromised a critical SCADA system, which led to massive explosion in a natural gas pipe line [1]. However, the incident was shrouded behind the cold war cloud. What made experts across the world standup was the Stuxnet attack in 2010 on Iranian enrichment plant that destroyed thousands of centrifuges [2]. Till that time, it was thought that cyber-attack would cause – directly or indirectly – financial/reputation damage only, but Stuxnet attack demonstrated that a cyber-attack on ICS could cause physical damage and even accidents. An experiment done in the USA demonstrated that an electrical generator can be blown up by a well-designed cyber-attack on its ICS. A series of cyber-attacks were witnessed in the last two decades targeting Critical Infrastructure such as energy, urban water/sewage systems, communication, etc. [2][3]. Noted among these are: massive attacks on Ukrainian power grid in 2015 & 2016 that caused blackout in a large area and rendered millions of people without power up to 6 hours; 2012 Shamoon attack on large oil sector companies in middle east; cyber-attack in 2000 at a sewage plant that released a million litres of untreated water.

In 2022, industry reports indicated 20 times increase in adversarial reconnaissance targeting Modbus/TCP port 502, a commonly used ICS industrial protocol, which could allow hackers to control physical devices and disrupt operations. SCADA systems are most targeted followed by PLC's used in ICS.

One study shows that about 10% attacks were made by in siders – which are very alarming as it is extremely difficult to handle insider attacks.
Statistics of the last decade shows that Critical Infrastructure appear in top five targeted industries with energy sector experiencing three times more attacks compared to the next industry in the list [3]. Nuclear plants were also attacked by virus/worms. Cyber-attacks in 2018 aimed at the US nuclear power plants breached corporate networks at power plants, but safety systems were untouched. Even in India, in 2019 cyber-attack was unleashed on Kudankulam NPP that could breach administrative network; but the ICS was safe and secure.

3. International Initiative on ICSS

In early 2000's the US came out with Code of Regulations (e.g. 10 CFR 73.54, 73.55) and Regulatory guides (e.g. RG 5.71, RG 1.15) that stipulated requirements for computer security to be incorporated in nuclear plants. Even before the Stuxnet attack, 10 CFR 73.1 had listed 'cyber-attack' as one of the design basis threats for a nuclear plant that the licensee needs to consider while designing the plant.

In mid-2010's International Atomic Energy Agency (IAEA) initiated a program to prepare guidance documents for the member countries in respect of computer security and in particular ICS security for nuclear plants. This author had contributed to one of its publications, namely, "Computer Security of Instrumentation and Control Systems at Nuclear Facilities" which is specifically applicable to ICS of nuclear facilities. Some of the IAEA's publications are listed in the reference [4][5].

During the last two decades most countries have produced regulatory and advisory documents for protecting ICS from cyber-attacks. Some of these are given in reference [10][11][12].

4.National Initiative on ICSS

National Critical Information Infrastructure Protection Centre (NCIIPC) was created in 2014 in India to protect Critical Information Infrastructure (CII's), which included: Energy, Finance, IT, Transport, etc. NCIIPC complements the Computer Emergency Response Team – India (CERT-IN), which covers all sectors and is responsible for collecting reports on all cyber-attacks / cyber-incidents. NCIIPC has produced many guidelines and policies for protecting CII's [6]; it also undertakes training and security exercise for CII's. It appears that NCIIPC has chosen an advisory role and it is not clear to what extent it has oversight on the implementation and maintenance of the necessary cyber-protections at the CII's.

Indian Power sector has come out with many regulatory and advisory documents for cyber-protection of ICS in power sector. Some examples are: Indian Electricity Grid Code (IEGC) 2023; IS-16335 :2015 Power Control Systems-Security Requirement; and CERC (Communication System for inter-State transmission of Electricity) Regulations, 2016.

DAE was among the first organisations in India that realized the risk due to cyber threat and the extent of damage it can cause. During 2014-17, DAE proceeded to make a comprehensive set of implementation guides – including that for security audit – to protect the instrumentation & control system of the Indian nuclear facilities. These documents provided guidance to identify the critical assets, to make a comprehensive risk-informed security plan, and its assessment throughout the system life-cycle. It also provided specific guidance on use of Commercial off-the Self (COTS) components, given that security risk of COTS are rarely fully mapped. These set of documents are mostly advisory in nature. Indian nuclear regulator is yet to come out with a comprehensive regulatory document on ICS security as has been done in most other countries and in Indian Power sector. This is especially important in post SHANTI Act era when private players would have significant stake in nuclear sector.

5. Threats & Vulnerabilities

Typical threats to computer-based ICS are [4][5][14]:

1. Introducing (deliberately/unintentionally) malicious code in software. This may happen during development or operation & maintenance (O&M) phase. The malicious code may be introduced via USB, CD-drive, Ethernet, etc. Malicious code could be virus, Trojan horse, time-bomb (which is dormant and acts at a particular time or condition of the plant), etc.
2. Unauthorized modification of software or set-points – leading to mal-operation, many times misleading the operator

3. Tampering of sensors or send erroneous data through network to give wrong information about the plant
4. Insider threat – covering all the above and even more

Vulnerabilities may exist in the product (e.g. the system or the software) as well as in the process (e.g. development). Listed below are some of the product vulnerabilities:

1. Inadequate security features (e.g. in access control) or bugs in application software - This allows potential attacker to gain control & alter the system resources
2. Unused/unprotected hardware such as USB, CD-drive etc.- These are means to introduce malicious code
3. Security holes in operating system (OS) - The attacker exploits inherent vulnerabilities of the OS to gain control of the system
4. Supply chain compromise of system/software components

Some of the process vulnerabilities are listed below:

1. Insecure development, testing or validation environment - This is exploited to mix malicious software with genuine software, making it very difficult to detect & eliminate.
2. Insecure / inadequate configuration management - Intermediate or final software products developed or verified are modified before integrating into the system. This is applicable to development phase as well as O&M phase

6. Life-cycle Methodologies for ICSS

As per NIST [10] standard, a Risk Management Framework as illustrated in Figure 1 should be applied to the ICS's and the organization. It starts with identification of critical digital assets (that are to be protected) and associated security levels, based on impact of security breach on the plant safety and security. Next, a set of security controls needs to be selected - based on the security levels – and be implemented. If there are controls that are infeasible for implementation, alternate controls should be used or adequate justification needs to be provided. Next, assessment (possibly independent assessment) is made to ensure that these security controls are implemented correctly, operating as intended, and producing the desired results. The 'Authorize' step involves a Risk Management Framework

management decision to authorize the operation of a system and explicitly accept the risks to operations, assets, and individuals based on the controls implementation (there is always a residual risk in any system/environment). This step is important as the risks are well understood and has been accepted at the organizational level. This step might also be considered to coincide with the regulatory authorization. Finally, keep monitoring changes in the systems and environment (e.g. change in functions or Design Basis Threat) and assess effectiveness of the existing controls. This cycle repeats forever and it is applicable during system development phase as well as during O&M.

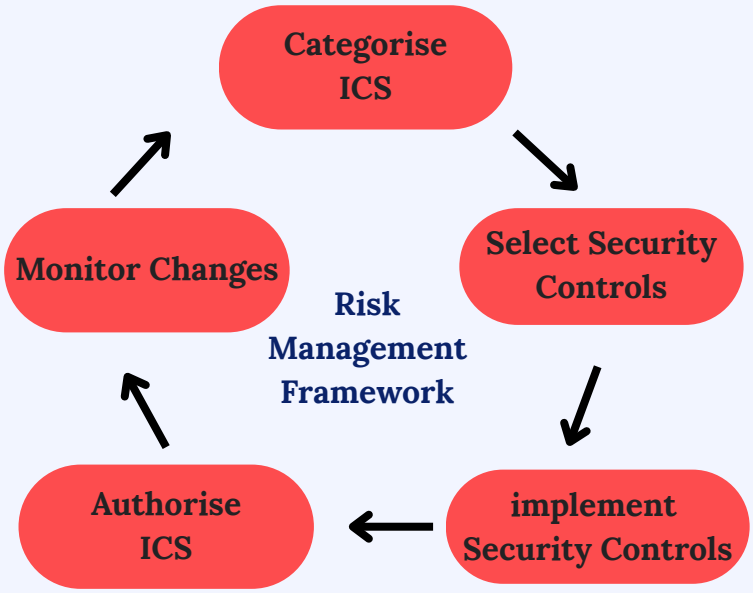


Figure 1 : Risk Management Framework

The risk management framework as applied to a system life-cycle is shown in Figure 2.

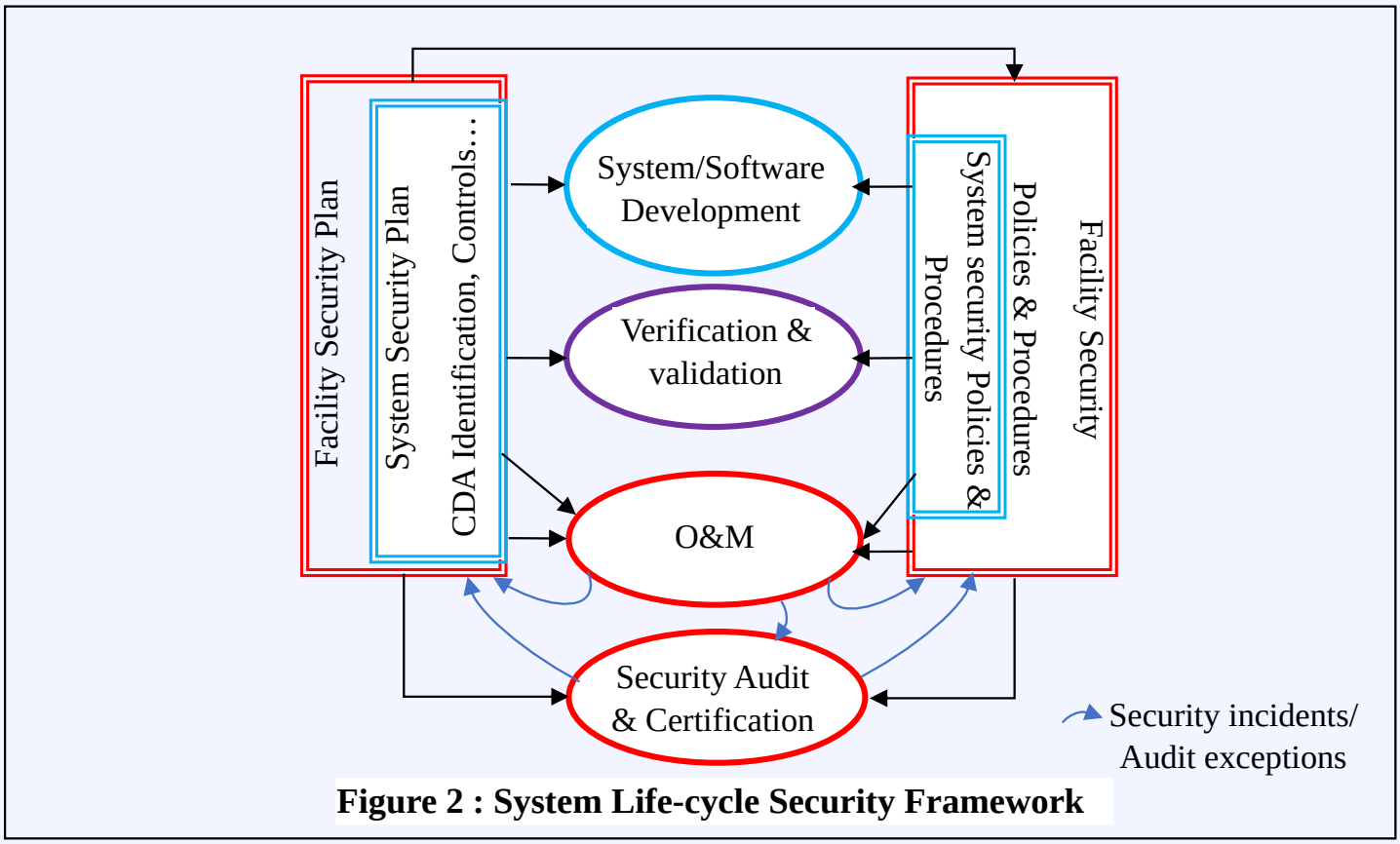


Figure 2 : System Life-cycle Security Framework

The organisation/facility security plan drives the system-wise security plans, which in turn define the security controls after Critical Digital Asset (CDA) identification. The security plans also provide inputs to the facility and system-wise security policies and procedures. The security controls, policies and procedures are inputs to the system/software development – requirements specification, design, coding/manufacturing and testing. These umbrella documents are also used during V&V of software/hardware to ensure correct implementation of the security controls and compliance to policies and procedures. During O&M, periodic assessment, security audit and certification are done to assure that overall security objectives are being met. During O&M, if any security incident occurs or if security audit brings out any anomaly, it could lead to revision of security plan, policies and procedures. This may or may not trigger changes in the system and execution of the entire change management cycle. In case of Critical Infrastructure such as nuclear facility, most of these activities – especially during O&M – would have regulatory oversight.

7. Design/Implementation Methodologies

ICS security implementation methods are innumerous. Due to paucity of space, a few important methods only are brought out. As mentioned earlier, ICS security can only be assured by security-by-design paradigm. Hence, focus is more on the design aspects.

a. Identification of critical assets and classification [4]: As mentioned earlier, one of the important steps in life-cycle security framework is identification of CDA's. Design is always a compromise between functionality and performance or other requirements. Hence, security controls selection uses a graded approach. This requires to categorise ICS at various security levels, depending on the impact of compromise of a system on the three security attributes: Integrity, Availability and Confidentiality of the ICS (Confidentiality is rarely considered in ICS), and its final impact on the safety and availability of the plant. Once the security levels are defined, risk informed system security requirements and a defensive ICS architecture can accordingly be designed.

The requirements (functional, qualification, acceptance) of highest security level are much more stringent than those at lower level and the architecture isolates/protects the interaction between systems at different security levels. This process ensures that overall risks to the plant get factored-in at the system level during the design process.

b. Trust model [3]: Trust model for data communication ensures that failures do not cross the security level boundaries. Zero-trust model is a security framework requiring all users, whether inside or outside the organization's network, to be authenticated, authorized, and continuously validated for security configuration and posture before being granting access to applications and data.

c. Segmentation and data diode: Data diode (unidirectional data link) is another concept, in which a higher security level system would pump data to a lower-level system, but physically it is impossible for the lower-level system to send data to a higher level system.

d. Air-gapping: the computer or network is physically isolated from other systems/networks. Even the smartest virus (say, AI powered one) will not be able breach this barrier. But care is to be taken that there are no unused ports/functions in the system which can be exploited by an insider.

8. Supply Chain Protection

In the last decade, supply chain has become one of the biggest ICS security concerns [4]. In the recent Israel-Palestine war we have seen how a pager device supply chain was compromised to make these devices explode at designated times. Similarly, ICS components could be compromised to malfunction at designated times/situations to bring down the plant operation to disarray. The Australian Government had blocked one Chinese Company in 2012 from building a National Broadband Network because of this concern.

DHS, USA and many other regulators require that critical network equipment and special cyber security products can only be sold after being certified by a qualified establishment, and must pass a national security review in compliance with national standard.

Although there is no single quick fix for supply chain protection, contract terms for vendors of ICS can include relevant cyber security clauses such as:

- Use of computer security design principles and best practices and applicable standards;
- Requirements for security screening assessments of design and support engineers, as well as any other personnel involved in system development (including subcontract vendors);
- Vulnerability scanning of designs and malware scan prior to system delivery;
- Secured and sanitized transport with specific security requirements for transit, storage and delivery of systems and components.

During O&M phase if ICS are serviced and maintained by external third-party vendors, appropriate computer security clauses may be included in the contract, such as:

- Vendor performs malware scanning using up-to-date malware definitions, both prior to and after connection of any removable media or portable device (which have up to date security controls) to ICS. Preferably, these devices should not go out of the plant premises.
- No remote connection

9. Other Approaches/Methodologies

There are many other approaches /methodologies that complement the one described in this article. Some of these attempts to quantify security attributes and some attempt to manage risks associated with various attack scenarios.

The risk management methodology uses a process that identifies the susceptibility of computer systems to sabotage, evaluates the system's robustness, and provides cost-effective counter measures to 'fix the holes'. Also, attempt is made to quantify security attributes, such as cost of attack and impact by modeling the attack scenarios using probabilistic techniques, attack trees and Markov chains [13][14].

Some examples of are [5][14]:

- Attack surface modeling: the composition of attack pathways through access points where an attacker can exploit vulnerability. Implementation of cyber security control methods mitigates the size of the attack surface by mitigating vulnerabilities and attack pathways.
- Threat modeling: focuses on the attacker and addresses possible adversaries, the motivations of those adversaries, attack vectors and possible goals of the adversaries.
- Scenario analysis: Using above mentioned models, one can create scenarios of various tasks on ICS and evaluate residual risk of these tasks in presence or absence of security controls – qualitatively or quantitatively.

10. Conclusion

AI-powered cyber-attacks are much more lethal as the vulnerabilities of the systems can be much better understood by these engines and the attack design and execution can be automated to make it cost-effective and to cause very high adverse impact on the Critical Infrastructures of a country. Protection of ICS from cyber-attacks needs to be assured using security-by-design concept, risk-informed life-cycle security models and deployment and maintenance of relevant security controls in ICS. Certified in-house and indigenous security products complying with stringent cyber security standards can greatly enhance resilience of Critical Infrastructures ICS against cyber-attacks.

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Gamma Ray Bursts : Shedding Light on the Cosmos

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Abstract: The Big Bang hypothesis makes scientifically accurate and testable predictions to understand the evolution of the universe. It is primarily based on the four key observational milestones including the expansion of the universe, nucleosynthesis, cosmic microwave background radiation, and large scale structure formation. These successes rely on the electromagnetic observations spanning more than twenty orders of magnitude in energy from radio to very high energy gamma rays along with other messengers such as cosmic rays, neutrinos and gravitational waves produced at different epochs during evolution of the universe. Gamma Ray Bursts, observed to be extremely energetic and luminous transient events frequently occurring in the sky, are considered as the most explosive phenomena in the history of universe after the Big Bang. These cosmic events emit bright flash of electromagnetic radiation lasting from less than a fraction of second to hour. They are detectable at deeper universe due to their enormous brightness and have potential to serve as a new observational probe to the evolution of the universe. In this contribution, we present the role of Gamma Ray Bursts as a cosmic beacon and high-light the astrophysical and cosmological importance of a recently detected gamma ray burst event GRB 250314A, which occurred when the universe was about less than one billion years old suggesting that the electromagnetic signal from GRB250314A travelled for approximately thirteen billion years to reach Earth on March 14th, 2025. This also suggests that the ancient stellar object that created GRB 250314A was not massive enough and it might resemble the progenitors of gamma ray bursts in the present day universe.

1. Introduction:

The word cosmos, which basically refers to the complex physical universe, has its origin from the Greek kosmos meaning order, harmony and the world. Cosmology, one of scientific triumphs of the 20th century, is defined as a discipline of science to study the origin, structure, dynamics and life of the universe. The advent of modern day cosmology is based on the idea of the Big Bang for the origin of the universe. The Big Bang is not a theory, but a plausible scenario about the early moments of our current universe. This scenario is based on a simple assumption that space, time, and energy already existed. But it still remains silent about their origin. Thus it is a misconception that the Big Bang was the origin of the universe. In reality, the Big Bang was not an explosion that happened somewhere in space but an expansion of space, incredibly hot and dense, itself. And, how the universe came into existence in the first place is still a mystery. The most conclusive piece of evidence that supported the Big Bang as a dominant paradigm for the origin of the universe is the discovery of the cosmic microwave background radiation (CMBR) in 1965. This radiation isotropically bathes our solar system, and is known to accurately take on the form of a black body with temperature of 2.75 K. The CMBR is basically a left over thermal radiation from the time when first hydrogen atoms were formed [1].

Detection of two lighter elements hydrogen and helium, throughout the universe, also supports the Big Bang hypothesis. These elements (75% hydrogen and 25% helium) are predicted to have been created during the Big Bang via nucleosynthesis [2].

The first stars began their life made of hydrogen, with heavier elements being generated via nuclear fusion reactions. This prediction is based on the well understood nuclear reactions-independent of the Einstein's theory of general relativity [3]. The standard Hot Big Bang model also provides a framework for the collapse of matter to form galaxies and other large-scale structures observed in the present universe [4]. It has now been widely accepted that the baryonic matter in the universe would not be sufficient to provide enough gravitational attraction alone for the formation of large structures observed today. This problem is circumvented by the introduction of non-baryonic dark matter, which provides the additional gravitational pull to allow structure formation more quickly and is not inhibited by pressure effects [5].

The general theory of relativity, proposed in 1916, has led to the development of several cosmological models and solutions to the Einstein's field equations described an expanding universe. However, the experimental demonstration of the idea of an expanding universe was proposed in 1929 by Edwin Hubble. It was observed that distant galaxies are receding from us. Since this remarkable demonstration, the recession velocity of millions of galaxies has been measured today. The accelerated expansion of the universe was finally discovered in 1998 through supernova observations [6]. This suggests that in the distant past everything in the universe was much closer together and the universe must have been much smaller in the past than its present size. The Einstein's theory of gravity provides a framework to look back in time and calculate the size or density of the universe in the past. This has enabled to estimate the current age of universe to be 13.8 billion years since the Big Bang. The size of observable universe is estimated as 93 billion light years [7]. A pictorial representation of the evolution of the universe since Big Bang is shown in Figure 1.

The standard cosmological model, a mathematical representation intended to capture in sufficient detail the physical processes relevant to describe the present universe, assumes that our universe consists of only ~ 5% baryonic matter, ~ 25% dark matter, and ~ 70% dark energy [8]. The dark energy, a dominant component of the current universe, has an energy density that does not change with time as the universe expands. It leads to the accelerated expansion of the universe by counterbalancing the action of gravity through a negative pressure.

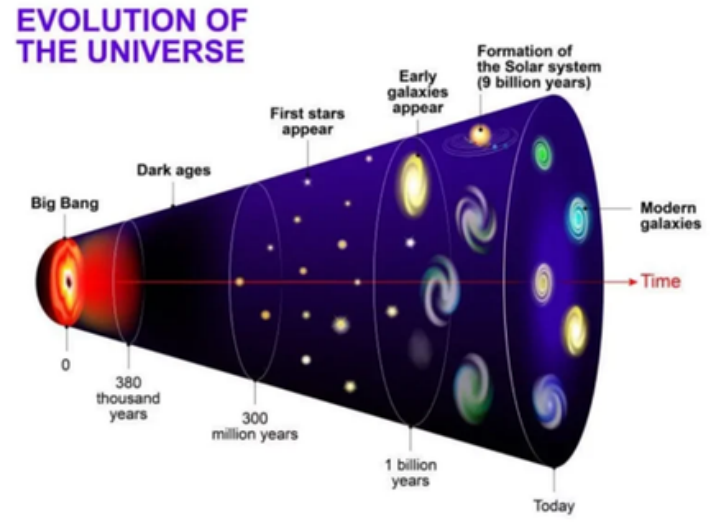


Figure 1: Expansion history of the universe. (Image Credit: https://pwonlyias.com)

The field of observational cosmology has witnessed several rapid advances over the last few decades with the multi-messenger probes of the universe. These probes include photons over a wide range of wavelengths in the electromagnetic spectrum from the radio to very high energy gamma-rays, ultra high energy neutrinos of the astrophysical origin, as well as the gravitational waves [9]. The wealth of observational data has led to the development of precision cosmology, whereby the cosmological parameters describing the present universe are measured with unprecedented accuracy. Gamma Ray Bursts have evolved as the potential targets for precision cosmology in the modern era of multi-messenger astronomy.

The multi-messenger, when detected, are usually associated with stellar explosion at the end of the life of massive stars, surface neighbourhood of compact objects such as neutron stars, white dwarfs, and black holes, supermassive black holes in the core of galaxies, or energetic shocks in relativistic plasmas. Deployment of the state-of-the-art astronomical instruments established the existence of active galactic nuclei, neutron stars, white dwarfs, black holes, and revealed dramatic high-energy transient phenomena, including X-ray novae, X-ray bursts and Gamma Ray Bursts. These associations with the violent astrophysical phenomena have implications for the theories of fundamental physics, including strong-field gravity, nuclear and particle physics beyond the standard model. Observations of different astrophysical sources and ensuing detailed studies, have realized the long standing dreams of the researchers and astrophysicists to probe the mysteries of the universe. This contribution mainly focuses on the Gamma Ray Bursts as a potential cosmic probe.

2. Gamma Ray Bursts:

Gamma Ray Bursts (GRBs) are considered as the most explosive transient phenomena after Big Bang in the universe. They have been puzzling the astronomers since their accidental discovery in late in the late 1960s [10]. The history of GRB discovery is interestingly linked to the nuclear tests carried out by the United States and the Soviet Union during the cold war in the early 1960s. A treaty was signed between the two countries to prohibit carrying out any nuclear weapon test in the atmosphere beyond a considered limit, including the outer space. The Department of Defence of the United States launched a space program known as Vela satellites to monitor the "Outer Space Treaty" that forbade all test detonations of nuclear weapons, except for those conducted under ground in 1963. These military satellite constellations were launched in pairs to triangulate the direction of nuclear tests.

An unprecedented burst of gamma-radiation, distinct from any previously identified astrophysical source, was suddenly detected by the CsI gamma-ray detectors on-board the Vela satellite on July 2nd, 1967. Utilizing the triangulation capabilities, it was emphasized that these explosions were not due to nuclear tests from outer space or the moon. After a meticulous study and analysis, the information was declassified and the first public announcement of these mysterious GRB was made public in 1973 [10]. This accidental and serendipitous discovery of GRB by the United States secret Vela satellites was quickly confirmed by the Soviet space satellite Konus/Venera [11] and by the observations on the American IMP-6 satellite [12]. Following this, GRBs, a wonderful by-product of the monitoring of nuclear explosion tests, marked the inception of a new era in astrophysical observations. However, first two decades after the GRB discovery are considered as a dark era in this budding field of research. In 1991, NASA launched the Burst and Transient Source Experiment (BATSE) instrument as part of the Compton gamma-ray Observatory with main objective of discovering and localizing a large number of GRBs [13]. After several years of BATSE observations, a map with the localization of 2704 GRBs was reported [14].

The modern era of GRB research started following the launch of the Neil Gehrels Swift satellite in 2004 [15] and Fermi Gamma Ray Space Telescope in 2008 [16,17] to discover X-ray/optical and high energy gamma-ray counterparts respectively. So far, a total of more than 15000 GRBs have been detected with a detection rate of about one GRB per day. The name of a GRB is given by the pattern "GRB YYMMDD". If more than one GRB is detected on the same day, letter A, B, C are added at last in the GRB name following their time of detection. For example, a GRB detected on March 14th, 2025, is named as GRB 250314A. Based on the decades of long observational evidences, GRBs are characterized as the sudden, violent, and cosmic explosions of gamma rays with an astrophysical origin.

The high energy gamma-ray emission from these transient cosmic events lasts from less than a fraction of second to tens of hundreds of second. The emission of radiation from GRBs takes place in two consecutive phases: prompt and afterglow [18]. The prompt phase is characterized as the initial high energy emission in gamma-ray and hard X-ray bands for duration of a few seconds to several hours. This is followed by the afterglow phase with multi-wavelength emission in lower bands for a longer period. During the prompt phase, a huge amount of energy-typically 1050-1053 erg is released in the form of gamma-rays in a very short time duration. Based on the prompt gamma-ray duration, GRBs are traditionally classified into two categories: short GRBs, with an average duration of less than 2 seconds and long GRBs corresponding to average duration of more than 2 seconds. The short GRBs are considered to originate from the merger of compact stars such as neutron star-neutron star or neutron star-black hole [19]. The long GRBs originate from the core collapse of massive stars [20]. A pictorial representation of the possible progenitors of short and long GRBs is depicted in Figure 2.

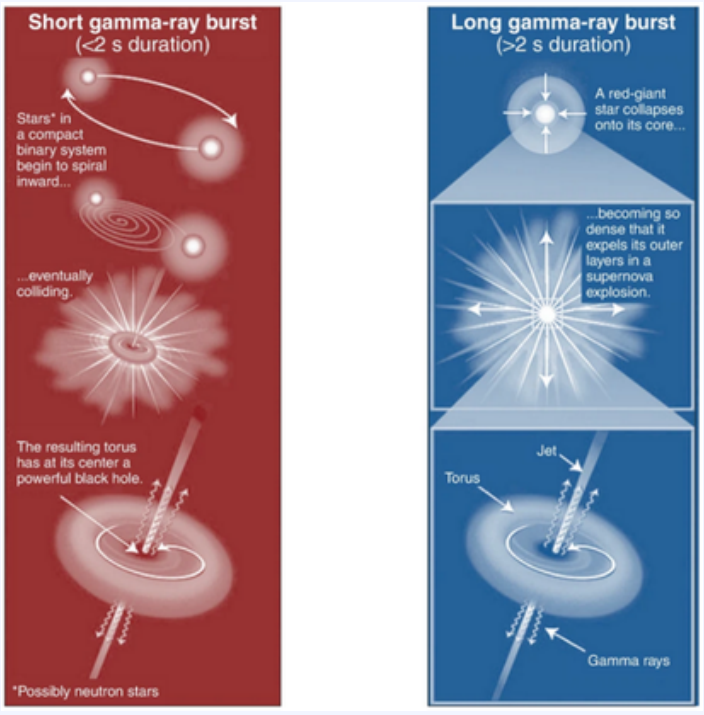


Figure 2: An artistic view of the origins of short and long GRBs. (Image Credit: https://www.nature.com/articles/s41550-021-01401-4).

There are growing observational evidences that some GRBs happen simultaneously with core-collapse supernovae [21]. A theoretical implication of this plausible link between two grandest explosions, GRB and supernovae, is that most long GRBs are accompanied by massive stellar explosions. However, the prompt emission prom GRBs still remains a mystery. It is expected to originate in a relativistic plasma jet via energy dissipation either in internal shocks when fast-moving shells collide with slower shells or due to catastrophic reconfiguration of magnetic fields [22]. The most famous relativistic Fireball Model is widely used to explain the complete GRB phenomena. As shown in Figure 3, the relativistically moving fireball is launched by a rotating black hole. The relativistic motion leads to the jetted emission from GRBs. An internal shock mechanism is responsible for the prompt emission and external shock for the afterglow emission [23]. Although the fireball model is well accepted for the basic picture of GRB formation and evolution, most of the physics details remain open questions even after more than five decades of extensive research in this field.

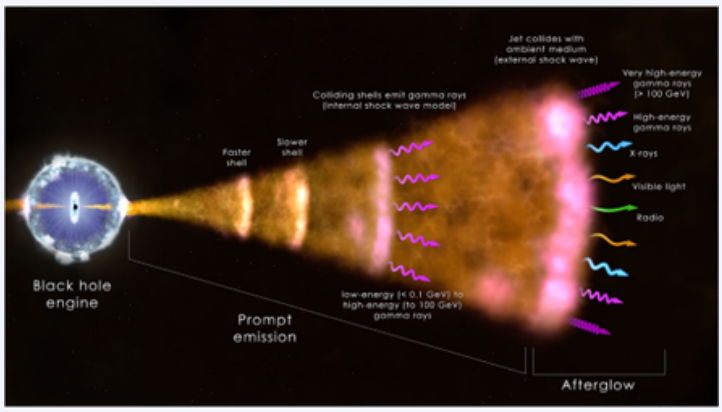


Figure 3: An artistic impression of the fireball model for GRBs. (Image Credit: NASA/Goddard Space Flight Center).

3. GRBs as Cosmic Beacon:

It has now been well established that the GRBs are extragalactic phenomena occurring at cosmological distances from the Earth. They arrive randomly from locations beyond our Milky Way Galaxy.

Using GRBs as the cosmic beacons is still in its infancy. They have been believed to be the potential emitters of multi-messengers since long. GRBs are considered to be dominant source of ultra-high energy cosmic rays [24, 25] and astrophysical neutrinos of PeV (1015 eV) energies [26,27]. Merger of compact objects such as two neutron stars as potential progenitors of some GRBs makes them ideal sources of gravitational waves together with high energy gamma-rays [28]. Detection of famous gravitational wave events GW170817 on August 17th, 2017, by the gravitational wave observatories in the USA and in Italy [29], and occurrence of a low-luminosity short GRB GRB170817A, 1.7 seconds later [30], was associated with the binary neutron star merger with an accurate localization. This historical joint detection had enormous importance for fundamental physics, as it was used to place stringent constraint on the difference between the speed of gravity and the speed of light [30]. These detections also had huge repercussions for dark matter and dark energy models, completely ruling out some classes of modified gravity theories that had been perfectly viable up to that detection [31]. A few GRBs have been observed to emit very high energy photons of TeV (1012 eV) energies by the ground-based gamma-ray observatories [32].

The cosmic formation rate of long GRB encodes the evolution of their progenitors and their environment across cosmic times. Therefore, they can be treated as a promising probe of the early universe as well as standard candles like the supernovae explosions with similar physical origin due to their high luminosity in the range 1046 – 1055 erg per second [33]. Such a high luminosity makes GRBs observable out to the largest distances yet to be explored in the deeper universe as they represent a new way of identifying a population of star-forming galaxies in the early universe.

The optical afterglows of GRBs seen in absorption provide a powerful new probe of the inter-stellar medium in the dense, central regions of their host galaxies. Thus, GRBs provide a unique route to investigate the properties of host galaxies which themselves are too faint to observe. They can also be standardized to be a cosmic distance indicator for cosmological purposes by using correlations between their observable quantities found in prompt and afterglow phases [34].

Due to their cosmological origin in deeper universe, GRBs can be used to bridge the blankness between local universe and the cosmic microwave background radiation resulting in placing constraints on the cosmological parameters [35,36]. Thus, GRBs, as bright beacons in the deep Universe, are the ideal tool to probe the properties of early universe: including the expansion rate and dark energy, star formation rate, and the metal enrichment history of the universe [37].

Apart from their astrophysical and cosmological importance, GRBs are thought to have some terrestrial impacts [38,39]. It is speculated that very intense GRBs can cause extinction-like events in Earth's history. The famous Ordovician-Silurian mass extinction, approximately 450 million years ago, is hypothesized to have occurred due to a nearby GRB event [40]. This aspect of the GRBs has also received a lot of attention in the scientific community.

4. GRB250314A:

The Space-based multi-band astronomical Variable Objects Monitor (SVOM), a new Sino-French mission, detected a 10 second long high energy signal on March 14th, 2025. This detection was subsequently localized as a GRB event namely GRB250314A [41]. The follow-up campaign led to the discovery of the near-infrared afterglow phase by Nordic Optical Telescope. An X-ray counterpart was also detected from this burst.

The James Webb Space Telescope (JWST) observed this event on July 1st, 2025, an epoch about 110 days post-burst [42]. It was able to detect the host galaxy and a likely supernova explosion event. The host galaxy was identified as a faint blue galaxy at a cosmological redshift of z ~ 7.

The astrophysical estimations suggest that the signal from GRB250314A have travelled for about 13 billion years to reach the Earth. This event is associated with a massive star explosion just 730 millions years after the Big Bang. The sky localization of this historical burst is shown in Figure 4. The cosmological importance this long GRB underlines the importance of GRBs as probes of star formation in the very early universe. The progenitor of GRB250314A is similar to that of a massive exploding star observed in the local universe. It is expected to play a pivotal role in exploiting the galaxy formation in very early universe during first billion year after the Big Bang.



Figure 4: Localization of GRB250314A detected by the SVOM satellite. (Image Credit: NASA, ESA, CSA, STScI; Andrew Levan, Radboud University, Image Processing- Alyssa Pagan).

5. Summary:

Gamma Ray Bursts are the extreme phenomena in the universe. They push the limits of the current physical theories.GRBs are referred to as the energy monsters of the universe as they come from the most energetic and rich of information events in the universe. GRBs are observed throughout the whole Electromagnetic Spectrum. They have received a lot of attention as promising astronomical candles as well as potential probes of an increasingly diverse range of pressing questions in contemporary physics, astrophysics and cosmology. Even after more than 50 years of their discovery, GRBs continue to intrigue scientists and drive on-going investigations as they relate to extreme astronomical transients. The recent detection of GRB250314A with a 10 second long high energy signal has opened a new window in understanding the GRB phenomena in the very early universe.

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Report of INS-sponsored Conference and Outreach Programme at ICFAI University, Tripura in July 20th-24th, 2026

"National Conference on Innovations in Nuclear Physics and its Application to Nuclear Power Generation (INP-NPG-2026)" was jointly organised by Department of Physics, The ICFAI University Tripura and Indian Nuclear Society (INS) at the university campus between July 20th and 24th. The event was in Hybrid mode (offline + online) and was attended by more than 100 participants from all around the country. This was the first time that such a major event on Nuclear Energy was being organised in the North East.

On July 20th, the main organiser of the conference, Prof Dipayan Chattopadhyay, Department of Physics welcomed all delegates and speakers. The conference was inaugurated by Prof Biplab Haldar, Vice Chancellor of ICFAI University. The Chief Guest, Dr Subir Sen, Director(T), Tripura State Electricity Corporation spoke on the relevance of the conference. Shri KU Agrawal, Join Secretary and Dr Debabrata Datta, Member-EC represented INS. After the inauguration, invited talks were given by Shri Agrawal, Dr Suruchi Jain of AIIMS, Bhopal and Dr Datta. The title of the talks is given in the table below.

S.No.	Speakers Name	Titles
1.	Shri Kishor U Agrawal	India's Nuclear Reset: From State Monopoly to Market Framework
2.	Dr. Suruchi Jain	Wonders of Nuclear Medicine (on-line)
3.	Dr. Debabrata Datta	National Nuclear Energy Mission of 100 GWe by 2047 and Shanti Act

At the end of day one, walkathon was organised to promote Public Awareness of Nuclear Science and Technology by the Indian Nuclear Society. A number of students and faculties including the host Prof Dipayan Chattopadhyay participated.

This event was organised in and around the campus of the ICFAI University for about one hour. It evinced interest in the public inside and outside the campus. For the event, students had prepared banners with slogans on peaceful use of nuclear energy.

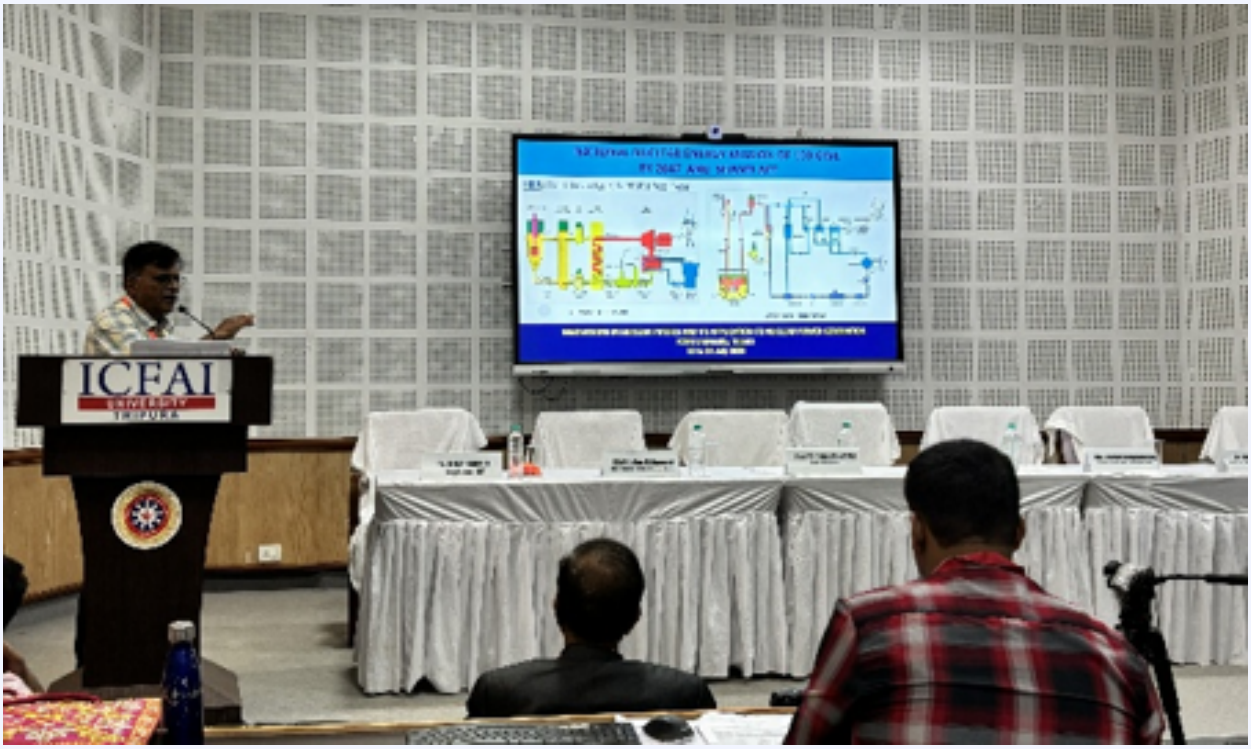
Few photographs of the conference and the outreach event can be seen below.



Welcome address by Prof Dipayan Chattopadhyay



Talk by Shri Kishore U Agrawal



Talk by Dr Debabrata Datta



Prepared by: Dr Debabrata Datta, Member, EC, INS

Report on one-day workshop on "Societal Aspects of Nuclear Energy: From the Core to the Citizen" At Department of Energy Science & Engineering, MANIT Bhopal

The Indian Nuclear Society (INS) Mumbai, organized a one-day workshop on **"Societal Aspects of Nuclear Energy: From the Core to the Citizen"** on **17th August 2026** at the Department of Energy Science & Engineering, Maulana Azad National Institute of Technology (MANIT), Bhopal. The workshop was organized with the objective of creating awareness among students, faculty and professionals about the beneficial applications of nuclear science and technology and their growing relevance to society for wellness of general public.

The programme was graced by **Dr. Sailendra Jain, Dean (Academic), MANIT Bhopal**, as the Chief Guest, and **Prof. V. K. Manchanda** as the Guest of Honour. The workshop brought together distinguished experts on diverse domains of nuclear science and technology that included **Shri S. K. Sinha, Shri Sanjay Chouksey, Dr. Jaideep Gupta, Shri K. T. P. Balakrishnan, Dr. Hrishikesh Mishra, Shri A. K. Sinha and Dr. Archana Mishra.**

Through a series of engaging technical talks, interactive discussions, and a panel session, the experts highlighted how nuclear science extends far beyond electricity generation to direct societal well-being. .

The discussions covered a wide spectrum of applications, including **nuclear energy, nuclear safety, healthcare and nuclear medicine, radiation technology, agriculture, food security, advanced technologies, and sustainable development.** The workshop emphasized how these technologies can be harnessed for emerging national challenges, be it climate change, healthcare, food secutity, agriculture and overall socio-economic development

The programme witnessed enthusiastic participation from more than 300 students, faculty members, and industry professionals. The workshop provided an opportunity to the students to know the applications of nuclear science beyond the conventional classroom curriculum. Interaction with experienced scientists and professionals also enabled students to gain insights into emerging career opportunities, research possibilities, and the role of young scientists and engineers in shaping India's technological future.

The successful organization of the workshop was made possible under the guidance of Dr. Arvind Mittal, Professor & Head, Department of Energy Science & Engineering and Convener, with dedicated coordination by Dr. Gurveer Singh, Dr. Meena Agrawal, and Dr. Hrishikesh Mishra.

The workshop provided a meaningful platform for knowledge exchange, scientific dialogue, and public engagement.



Gathering of students, officials of MANIT and visiting experts



Interactive session.

Prepared by Dr H Mishra, Member INS

Report on Public Awareness Programme on "The Role of Mass media in the success of Nuclear Energy Technology" At Makhanlal Chaturvedi University, Bhopal

The Indian Nuclear Society (INS), Mumbai, organized a public awareness programme on "The Role of Mass Media in the Success of Nuclear Energy Technology" on 17th August 2026 at Makhanlal Chaturvedi National University of Journalism and Communication, Bhopal. The programme was aimed at creating awareness among students and faculty members about the wide-ranging applications of nuclear science and technology and highlighting the important role of mass media in communicating its benefits to society.

The programme was graced by Shri Vijay Manohar Tiwari, Vice-Chancellor, Makhanlal Chaturvedi National University of Journalism and Communication, Bhopal, as the Chief Guest, with Prof. V. K. Manchanda as the Guest of Honour. Distinguished experts, including Shri A. K. Sinha, Shri O. P. Rai, Dr. Hrishikesh Mishra, and Dr. Archana Mishra, shared their knowledge and experiences with the participants.

The technical sessions covered diverse aspects of nuclear science and its relevance to India's development. Prof. V. K. Manchanda provided an insightful overview of India's 70-year nuclear journey, highlighting the major milestones achieved by the country and the initiatives undertaken by the Government of India towards realizing the ambitious target of 100 GW of nuclear power by 2047. Dr. Hrishikesh Mishra presented about the management and utilization of processed radioactive waste generated by operating nuclear plants. He explained the process and technology for processed, reprocessed nuclear waste for various beneficial applications. Adding a motivational dimension to the programme, Shri A. K. Sinha delivered an engaging talk incorporating valuable professional and life lessons. His interaction emphasized the importance of dedication , perseverance , continuous learning, and a positive approach towards building a successful career and meaningful life. Dr. Archana Mishra highlighted the important role of nuclear radiation in sustainable agriculture and food security. She emphasized that nuclear techniques can contribute to enhanced agricultural productivity, food security, resource sustainability, and climate-resilient agriculture. Shri O. P. Rai emphasized the significant role of the Indian Nuclear Society in creating awareness and promoting a scientifically informed understanding of nuclear science and radiation technology. He highlighted the need for effective communication between the scientific community, media, students, and the general public so that the benefits of nuclear technology can be communicated accurately and responsibly.

The event witnessed enthusiastic participation from more than 200 students and faculty members. The programme helped participants appreciate that nuclear science is not limited to power generation but has its applications across several sectors that directly benefit quality of life and overall socio-economic development.

The programme was organized under the guidance of Dr. P. Shrivastava, Head, Department of Advertising & Public Relations and Department of Cinema Studies, and Convener, with dedicated coordination by Dr. Deepika Saxena, Shri O. P. Rai and Shri A. K. Sinha.

Overall, the programme served as an effective platform for scientific outreach, public awareness, and knowledge exchange, reinforcing the message that informed communication and responsible media engagement are essential for building public confidence and understanding of nuclear science. The event received coverage in various leading newspapers, including Dainik Jagran and other prominent media outlets.



Gathering of students, faculty and expert speakers



Speakers who made the event successful

'परमाणु ऊर्जा को सरल भाषा में समझाए मीडिया'

सिटी रिपोर्टर • माखनलाल यूनिवर्सिटी में सोमवार को 'परमाणु ऊर्जा तकनीक की सफलता में मास मीडिया की भूमिका' विषय पर वर्कशॉप का आयोजन हुआ। कार्यक्रम में वैज्ञानिकों और मीडिया विशेषज्ञों ने परमाणु ऊर्जा से जुड़े मिथकों, संभावनाओं और जनजागरूकता में मीडिया की भूमिका पर चर्चा की।

आईएनएस अध्यक्ष वीके मनचंदा ने कहा कि परमाणु ऊर्जा को लेकर समाज में मौजूद डर और भ्रांतियों को दूर करने के लिए वैज्ञानिक तथ्यों को सरल भाषा में लोगों तक पहुंचाना जरूरी है। बीएआरसी की डॉ. अर्चना मिश्रा ने बताया कि परमाणु तकनीक का इस्तेमाल बिजली उत्पादन के अलावा कृषि में भी हो रहा है। डॉ. ऋषिकेश मिश्रा ने बताया कि भारत वर्तमान में 8.8 गीगावाट परमाणु ऊर्जा विकसित कर रहा है और इसे 100 गीगावाट तक ले जाने का लक्ष्य है। वैज्ञानिक अनादि कुमार सिन्हा ने विद्यार्थियों को टीमवर्क, संचार और समय प्रबंधन के गुर बताए।

परमाणु वैज्ञानिकों से रूबरू होंगे स्टूडेंट्स

सिटी रिपोर्टर • माखनलाल चतुर्वेदी राष्ट्रीय पत्रकारिता एवं संचार विश्वविद्यालय में 17 अगस्त को परमाणु ऊर्जा के प्रति रुचि बढ़ाने के लिए एक विशेष कार्यक्रम आयोजित किया जा रहा है। इंडियन न्यूक्लियर सोसाइटी (आईएनएस) मुंबई की ओर से आयोजित कार्यक्रम स्टूडेंट्स को परमाणु वैज्ञानिकों के साथ बातचीत करने का मौका देगा।

विश्वविद्यालय के जनसंपर्क विभाग के विभागाध्यक्ष प्रो. पवित्र श्रीवास्तव ने बताया - कुलगुरु विजय मनोहर तिवारी की अध्यक्षता में आयोजित इस कार्यक्रम में आईएनएस मुंबई के वरिष्ठ सदस्य और देश के प्रमुख परमाणु वैज्ञानिक शामिल होंगे। इनमें भाभा एटॉमिक रिसर्च सेंटर के पूर्व विशिष्ट वैज्ञानिक विजय कुमार मनचंदा, वैज्ञानिक ऋषिकेश मिश्रा, एनपीसीआईएल के रिटायर्ड एसोसिएट डायरेक्टर अनादि कुमार सिन्हा, बार्क के वरिष्ठ वैज्ञानिक अर्चना मिश्रा और पूर्व वैज्ञानिक ओपी राय शामिल हैं।

एमसीयू में परमाणु ऊर्जा तकनीक की सफलता पर विशेष सत्र 17 को

भोपाल। माखनलाल चतुर्वेदी राष्ट्रीय पत्रकारिता एवं संचार विश्वविद्यालय (एमसीयू) में 17 अगस्त को इंडियन न्यूक्लियर सोसाइटी (आईएनएस), मुंबई के सहयोग से परमाणु ऊर्जा तकनीक की सफलता और इसके लाभकारी उपयोग पर विशेष जागरूकता सत्र आयोजित होगा। कुलगुरु विजय मनोहर तिवारी की अध्यक्षता में होने वाले कार्यक्रम में देश के वरिष्ठ परमाणु वैज्ञानिक विद्यार्थियों और फैकल्टी से संवाद करेंगे। विश्वविद्यालय के जनसंपर्क विभागाध्यक्ष प्रो. पवित्र श्रीवास्तव ने बताया कि कार्यक्रम में पूर्व विशिष्ट वैज्ञानिक एवं आईएनएस अध्यक्ष विजय कुमार मनचंदा, सेवानिवृत्त एसोसिएट डायरेक्टर एवं उत्कृष्ट वैज्ञानिक ऋषिकेश मिश्रा, पूर्व एसोसिएट डायरेक्टर एवं उत्कृष्ट वैज्ञानिक, एनपीसीआईएल अनादि कुमार सिन्हा, वरिष्ठ वैज्ञानिक बीएआरसी श्रीमती अर्चना मिश्रा तथा पूर्व वैज्ञानिक एनपीसीआईएल एवं आईएनएस कोषाध्यक्ष ओ.पी. राय शामिल होंगे। विशेषज्ञ परमाणु विज्ञान की प्रगति, स्वच्छ ऊर्जा, स्वास्थ्य, कृषि, खाद्य संरक्षण और जनसंचार में परमाणु तकनीक की भूमिका पर चर्चा करेंगे।

देश के परमाणु वैज्ञानिकों ने छात्रों ने किया संवाद, बताया यह दुनिया का भविष्य

परमाणु विनाश नहीं विकास का नया सोर्स, इसके प्रति डर ठीक नहीं

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भोपाल. परमाणु ऊर्जा भविष्य है। ये तबाही नहीं बल्कि बेहतर सेहत, एग्रीकल्चर में बहुत कारगर है। ऊर्जा संकट के दौर में इससे आत्मनिर्भर हो रहे हैं। इसका डर भ्रांति है। यह बात देश के परमाणु वैज्ञानिकों ने छात्रों से रूबरू होते हुए कही। वैज्ञानिकों ने स्पष्ट किया कि परमाणु ऊर्जा का उपयोग केवल बिजली बनाने या हथियारों तक सीमित नहीं है, बल्कि इसका सीधा संबंध हमारी थाली, खेती और सेहत से है। इंडियन न्यूक्लियर सोसाइटी के अध्यक्ष और देश के वरिष्ठ परमाणु वैज्ञानिक वीके मनचंदा सहित भाभा परमाणु अनुसंधान केंद्र के वैज्ञानिकों ने छात्रों से संवाद किया। आयोजन माखनलाल चतुर्वेदी विवि में हुआ। इन्होंने बताया अनजाना डर है। इसे दूर करने में मीडिया की भूमिका महत्वपूर्ण है।



छोटी में परमाणु चमत्कार: 72 नई किस्में और 8 महीने तक आलू-प्याज की सुरक्षा: भाभा परमाणु अनुसंधान केंद्र की वैज्ञानिक डॉ. अर्चना मिश्रा ने बताया कि विकिरण तकनीक से कृषि क्षेत्र में क्रांतिकारी बदलाव आए हैं। मूंगफली केले सहित फसलों की 72 उन्नत किस्मों का विकास किया है। प्याज और आलू के अंकुरण को रोककर उनकी भंडारण क्षमता 8 महीने तक बढ़ा दी गई है।



ये वैज्ञानिक शामिल

इंडियन न्यूक्लियर सोसाइटी के प्रेसिडेंट वीके. मनचंदा, विशिष्ट अतिथि वैज्ञानिक अनादि कुमार सिन्हा, ओपी राय, डॉ. अर्चना मिश्रा, डॉ. ऋषिकेश मिश्रा उपस्थित रहे। कुलगुरु विजय मनोहर तिवारी, कुलसचिव पी शशिकला, डीन अकादमिक डॉ. मनीष माहेश्वरी सहित स्टूडेंट सेशन में शामिल रहे।

कचरा से भी ऊर्जा, 100 गीगावाट का बड़ा लक्ष्य: तकनीकी सत्र में डॉ. ऋषिकेश मिश्रा ने 'न्यूक्लियर फ्यूल साइकल' के बारे में बताया। कहा इस्तेमाल हो चुके ईंधन (स्पेंट फ्यूल) के रीप्रोसेसिंग मॉडल से कचरे को भी संसाधन में बदला जा रहा है। भारत वर्तमान में 8.8 गीगावाट परमाणु ऊर्जा का उत्पादन कर रहा है, जिसे बढ़ाकर 100 गीगावाट तक ले जाने का लक्ष्य रखा गया है।



परमाणु का डर निकालने देश में हो रहा काम, अनुसंधान के स्कालरशिप: इंडियन न्यूक्लियर सोसाइटी देशभर में परमाणु ऊर्जा से जुड़े डर को खत्म करने के लिए काम कर रही है। इसी कड़ी में आयोजन था। संस्था की स्थापना 1988 में जेआरडी टाटा ने की थी। 5600 सदस्य हैं। अमेरिकन, फ्रेंच व जापानी न्यूक्लियर सोसाइटी के साथ एमओयू हैं। आईएनएस एफटीजीएस छात्रवृत्ति दे रहा है। यह परमाणु अनुसंधान में मदद करती है।

Report on the INS-BHEL Training Program held at HRDI, NOIDA

INS is indeed fortunate to have large pool of experts as its members who have 3-4 decades of professional experience in nuclear science and technology and are a source of strength for its activities in general and training programs in particular. Society has been in the forefront in providing training to PSUs / Private industries in the areas of their interest related to nuclear industry and has organised several workshops for two decades . As per its mandate, INS is committed to support industry as well as academic institutes to facilitate the achievement of target of 100 GWe nuclear power by 2047. Present training program for BHEL is an important step in this direction. INS has been able to mobilise distinguished nuclear Scientists and Technologists from all over the country for this program who have also been associated with Training / Teaching activities for decades. A comprehensive curriculum has been designed specifically for the BHEL officers who may take up assignments related to the expanding nuclear power sector of the country in future. Annexure summarises the detailed schedule of the first phase of four weeks program covering Fundamentals of Nuclear / Reactor Physics and Overview of Nuclear Power Reactors conducted from 20th July to1st August, 2026. Training Program included weekly exams and feedback of the faculty. Other topics viz. Reactor Materials and Radiation Protection and Shielding will be covered in Sept-Oct, 2026.

Report Prepared by Dr V.K.Manchanda

BHEL Training Schedule MODULE-1
Course No: 1
Course Name: Basics of Nuclear and Reactor Physics
INS Co-ordinator: Shri S.K. Sinha (M: 9969053158)

Day-1

Lecture No.	Topic	Faculty Name
1	Nuclear Structure and stability	Dr. B.S. Tomar
2	Introduction to Radioactivity	Dr. B.S. Tomar
3	Radioactive decay types and energetic	Dr. B.S. Tomar
4	Introduction to Nuclear Fission & Fusion reactions	Dr. K. Devan
5	Concept of Fissile & Fertile nuclides; Neutron sources	Dr. K. Devan

Day-2

Lecture No.	Topic	Faculty Name
1	Interaction of ionizing radiations with matter	Dr. B.S. Tomar
2	Introduction to Radiation detection and measurement	Dr. B.S. Tomar
3	Types of Detectors and Selection Criteria	Dr. B.S. Tomar
4	Neutron-nucleus interactions	Dr. K. Devan
5	Introduction to Nuclear reaction Cross-section	Dr. K. Devan

Day-3

Lecture No.	Topic	Faculty Name
1	Core materials and their Neutronic properties	Dr. K. Devan
2	Types of Fuel and Criticality of Nuclear reactors	Dr. K. Devan
3	Introduction to Neutron diffusion theory	Shri S.K. Singh
4	Slowing down of neutrons	Shri S.K. Singh
5	Multiplication factors and Four factor formula	Shri S.K. Singh

Day-4

Lecture No.	Topic	Faculty Name
1	Concept of Criticality and Criticality Equations based on diffusion theory	Shri S.K. Singh
2	Introduction to Reactor core shapes and configuration	Dr. M.P.S. Fernando
3	Criticality conditions for different core shapes and configuration	Dr. M.P.S. Fernando
4	Reactor Kinetics: Simplified kinetic equation	Dr. M.P.S. Fernando
5	Reactor Kinetics: Reactivity and Period	Shri S.K. Singh

Day-5

Lecture No.	Topic	Faculty Name
1	Reactor Kinetics: Control parameters	Shri S.K. Singh
2	Reactor Operational Physics: Concept	Shri S.K. Singh
3	Reactor Kinetics: Control elements	Dr. M.P.S. Fernando
4	Reactor Operational Physics – Control parameters	Dr. M.P.S. Fernando
5	Reactor Operation Physics: Operational states, Power control & Measurement	Dr. M.P.S. Fernando

BHEL Training Schedule MODULE-1
Course No: 2
Course Name: Overview of Nuclear Power Reactors P
INS Co-ordinator: Shri M.K. Mathur (M: 9969161466)

Day-1

Lecture No.	Topic	Faculty Name
1	General Overview of Current Indian Reactors	Shri Mukesh Singhal
2	Classification and function of Nuclear Reactors	Shri S. K. Ghosh
3	General concept of reactor SSC	Shri S. K. Ghosh
4	Features of PHWR and PWR	Shri S. K. Ghosh
5	Concepts of Reactor Criticality	Shri V. K. Sharma

Day-2

Lecture No.	Topic	Faculty Name
1	Design features of BWR, GCR, AGR, HTGR and LMCFR	Shri S. K. Ghosh
2	Reactivity and Reactor Control	Shri V. K. Sharma
3	Generation IV reactors, SMR concept and goal	Shri S. K. Ghosh
4	Heat Removal - Primary System, Secondary System (PHWR)	Dr G. Vaidyanathan
5	Safety principles and Fundamentals	Shri R. Venkataraman

Day-3

Lecture No.	Topic	Faculty Name
1	Reactivity Feedback Mechanisms	Shri V. K. Sharma
2	Critical Safety Requirements	Shri R. Venkataraman
3	Heat Removal - Primary System, Secondary System (PWR)	Dr G. Vaidyanathan
4	Nuclear Reactor Control Systems	Shri V. K. Sharma
5	Heat Removal - Primary System, Other Systems (BWR)	Dr G. Vaidyanathan

Day-4

Lecture No.	Topic	Faculty Name
1	PHWRs-220 MWe	Shri Mukesh Singhal
2	Reactor Start-up, Power Operation, and Shutdown	Shri V. K. Sharma
3	Emergency operational Scenarios	Shri R. Venkataraman
4	Heat Removal-Primary System and secondary system (FBR)	Dr. G. Vaidyanathan
5	PHWRs-540/700 MWe	Shri Mukesh Singhal

Day-5

Lecture No.	Topic	Faculty Name
1	Safety Analysis	Shri V. K. Sharma
2	BWR-TAPS-1&2, VVER-1000 MWe	Shri R. Venkataraman
3	FBTR-40 MWth,PFBR-500 MWe	Dr G. Vaidyanathan
4	Passive Decay Heat Removal / Shutdown Systems	Shri V. K. Sharma
5	Accident Management	Dr G. Vaidyanathan

A glimpses of the programme can be seen in the photographs given below:




बी एच ई एल सदन



Report on 80th Independence Day Celebration

INS and AERWA jointly celebrated 80th Independence day on 15th August 2026. The chief guest of the programme was Dr. U. Kamachi Mudali, Vice Chancellor, HBNI. The programme was attended by members of both INS and AERWA. The programme began with hoisting of National Flag by the chief guest. It followed by singing of National Song, address to the gathering by chief guest and address by President INS. President AERWA gave vote of thanks. The programme ended with the singing of National Anthem.

The chief guest in this address informed the gathering about several firsts which marked this Independence day. Amongst them were singing of National Song, simultaneous translation of PM address into 22 languages using AI and use of make in India security gadgets for surveillance.

After the flag hoisting programme, Shri Anadi Sinha, an EC member delivered lecture on development of soft skill to INS and AERWA members.

Photographs of the Programme







Report on INS outreach programme at VIT Bhopal
19th August, 2026

INS outreach programme was conducted on 19th August, 2026 at VIT, Bhopal. The INS EC members who attended the programme were Dr. V.K. Manchanda, President INS, Shri O.P. Rai, Treasurer INS, Shri SK Sinha, Shri KTP Balakrishnan, Dr.H. Mishra, Dr. Archana Mishra and Shri AK Sinha. Lectures on the following topics were delivered by the respective speakers:

S.No.	Topics	Speaker
1	Atomic Energy Program in India : Journey of seven decades	Dr. V.K. Manchanda
2	Nuclear Reactor Technology	Shri S.K. Sinha
3	Safety culture in Nuclear Facilities	Shri KTP Balakrishnan
4	Nuclear Waste Management – Wealth from Waste	Dr. H. Mishra
5	Nuclear Radiation for sustainable Agriculture and Food	Dr. Archana Mishra
6	From Campus to corporate: Decoding Secret to Guaranteed Success	Shri A.K. Sinha

The programme was well received both the Management and the students. Nearly 200 students attended the programme. Several queries were asked by students both during the lectures as well as during lunch and the end of programme.

A glimpses of the programme can be seen in the photographs given below:









1). Reactor Restart Rekindling Japan's Nuclear Renaissance

https://www.powermag.com/reactor-restart-rekindling-japans-nuclear-renaissance/?oly_enc_id=1950A0974023F5V

2). Saeul 3's Nine-Year Nuclear Odyssey to Operation

https://www.powermag.com/saeul-3s-nine-year-nuclear-odyssey-to-operation/?oly_enc_id=1950A0974023F5V

3). The wait for a large gas turbine now runs longer than the time it takes to design, permit, and build the plant it will sit in.

https://www.powermag.com/is-the-smart-money-buying-operators-rather-than-%20megawatts/?oly_enc_id=1950A0974023F5V

4). AI factories are creating a fundamentally new type of power demand

https://www.powermag.com/ai-data-centers-demand-a-new-model-for-power-infrastructure/?oly_enc_id=1950A0974023F5V

5). Renewable Energy Surges, but Grid Crisis Looms as Demand Grows and Policies Shift

https://www.powermag.com/renewable-energy-surges-but-grid-crisis-looms-as-demand-grows-and-policies-shift/

6). Carbon-Free Energy Is the Name of the Game: Renewables, Nuclear Poised for Growth

https://www.powermag.com/carbon-free-energy-is-the-name-of-the-game-renewables-nuclear-poised-for-growth/

7). Juniper Green Energy Commissions New Wind Farms Across India

https://www.powermag.com/juniper-green-energy-commissions-new-wind-farms-across-india/?utm_source=omeda&utm_medium=email&utm_campaign=pwrrenewable+eletter&oly_enc_id=1950A0974023F5V

8). Bechtel-Westinghouse Group, PEJ Agree on Terms for Poland's First Nuclear Power Plant

https://www.powermag.com/bechtel-westinghouse-group-pej-agree-on-terms-for-polands-first-nuclear-power-plant/?utm_source=omeda&utm_medium=email&utm_campaign=pwrnews+eletter&oly_enc_id=1950A0974023F5V

9). Purdue Nuclear Reactor Test Demonstrates Remote, Automated Power Control

https://www.powermag.com/purdue-nuclear-reactor-test-demonstrates-remote-automated-power-control/?utm_source=omeda&utm_medium=email&utm_campaign=pwrnews+eletter&oly_enc_id=1950A0974023F5V

10). A New Chapter in India's Nuclear Journey

https://www.pib.gov.in/FactsheetDetails.aspx?Id=150617&lang=1&reg=3

11). Nuclear Energy Technology in India

https://static.pib.gov.in/WriteReadData/specificdocs/documents/2026/aug/doc_9724_20260828_10354401.pdf

12). Nuclear Power in India: Current and future projections

https://www.google.com/search?q=New+in+Indian+Nuclear+power+program&rlz=1C1CHBD_enIN1030IN1030&oq=New+in+Indian+Nuclear+power+program&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIKCAEQABgKGBYYHjINCAIQABiGAxiABBiKBTINCAMQABiGAxiABBiKBTINCAQQABiGAxiABBiKBTINCAUQABiGAxiABBiKBdIBCjE4MjA4ajBqMTWoAgiwAgHxBWhLrTm_cwOc&sourceid=chrome&source=chrome.rb&ie=UTF-8

Compiled by Dr. A. Rama Rao,
INS member

