

# iTrust Times

A Quarterly Newsletter

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## i for International

Dear Reader:

Greetings from iTrust!

Yet another instance of Locked Shields is behind us. This was the second time iTrust was invited to participate in the world's largest cyber exercise, aimed at training NATO member countries in cyber defence.

The exercise, held in April this year, deployed the full 6-stage version of the SWaT digital twin. The twin served as a target of pre-planned attacks while cyber defence teams from NATO member countries defended against the attacks. This was the first time iTrust contributed to both the green and red teams during the exercise.

Also for the first time iTrust made its presence known during the CCDCOE's annual conference. The conference, named CyCon, is the CCDCOE's annual flagship in-person event, held from 31 May to 3 June 2022 in Tallinn, Estonia. iTrust was a gold sponsor at CyCon and prominently displayed the SWaT digital twin at a dedicated booth. iTrust researchers made two presentations during the conference, one related to the cyber defence technologies and another describing iTrust's annual cyber exercises held since 2015. Needless

to mention, participation in Locked Shields and CyCon has raised iTrust's engagement with NATO to a new level.

iTrust continues to offer its resources for manpower training. The SWaT digital twin is now available to researchers and students. Faculty and researchers from the academia can request iTrust for remote access to the twin. The twin can be attacked remotely and data collected for assessing the effectiveness of cyber defence mechanisms. Most recently, students from the MSSD graduate programme at SUTD and another programme at the University of Bristol, were the earliest users of the twin.

For more news about iTrust, I invite you to browse this newsletter. Happy reading and best wishes to all readers of iTrust Times!

Aditya Mathur

Centre Director, iTrust, SUTD

Director, National Satellite of Excellence DeST-SCI

Professor Emeritus, Computer Science, Purdue University

## Locked Shields 2022

**Locked Shields is the world's largest and most complex international real-time cyber defence exercise, organised by the NATO Cooperative Cyber Defence Centre of Excellence (CCDCOE) in Tallinn, Estonia**

*Reproduced from NATO CCDCOE's website*

During two days more than 2,000 participants from 32 nations practise the protection of national IT systems and critical infrastructure under the pressure of a large-scale cyberattack at the annual live-fire cyber defence exercise Locked Shields. In addition to protecting numerous cyber-physical systems the participating teams practice tactical and strategic decision making, cooperation and the chain of command in a crisis situation where they also have to tackle forensic and legal issues and respond to information operations challenges.

The annual real-time network defence exercise is a unique opportunity for cyber defenders to practise protection of national IT systems and critical infrastructure under the pressure of a severe

cyberattack.

Col Jaak Tarien, Director of the NATO-accredited cyber defence hub says that organizing Locked Shields is a huge responsibility to CCDCOE. "Our Centre's member nations have designated Locked Shields as the premier annual training event for their top-tier national cyber defense teams. Justifiably, the expectation is that each year Locked Shields is on the cutting edge, challenging and superbly run world-class event. If our member nations send us their absolute best for training, we do not intend to disappoint," comments Col Tarien. According to Carry Kangur, Head of Cyber Exercises at CCDCOE, this years' exercise had the opportunity to be planned mostly on-site and less remote as the COVID-19 situation has eased. Additionally, there were quite a few new partners introduced, which made organising the whole exercise easier.

According to the scenario, a fictional island country located in the northern Atlantic Ocean, Berylia, is experiencing a deteriorating security situation as there have been a number of coordinated cyberattacks against Berylian military and civilian IT systems. These



**Fig 1: Locked Shields 2022 was held from Apr. 19 to 22, 2022 with over 2,000 participants from 32 nations. Photo credit: NATO CCDCOE**



**Fig 2: A core team at iTrust supporting Locked Shields 2022**

attacks have caused severe disruptions to the operation of government and military networks, communications, water purification systems and the electric power grid and eventually lead to public unrest and protests. For the first time the exercise includes the simulation of a reserve management and financial messaging systems of a central bank. Additionally, a 5G Standalone mobile communication platform is deployed as part of a critical infrastructure to give the first experience to cyber defenders about upcoming technology change. Exercise Locked Shields is a Red Team (RT) vs. Blue Team (BT) exercise with Teams formed by member nations and partners of CCDCOE. In 2022 there are 24 BTs participating with an average of 50 experts in each team. The teams take on the role of national cyber Rapid Reaction Teams that are deployed to assist a fictional country in handling a large-scale cyber incident with all its implications. The Exercise involves about 5,500 virtualised systems that are subject to more than 8,000 attacks. In addition to securing complex IT systems, the participating teams must also be effective in reporting incidents and solving forensic, legal, media operations and information warfare challenges.

In total there are more than 2,000 participants from 32 nations expected to be involved in Locked Shields 2022. The exercise is organised by CCDCOE in cooperation with NATO, Siemens; TalTech; Clarified Security; Arctic Security; CR14. The Centre also acknowledges the unique elements added to Locked Shields 2022 by Microsoft, the Financial Service Information Sharing and Analysis Center (FS ISAC), SpacelT, Fortinet.

# 14th International Conference on Cyber Conflict

CyCon is organised by the NATO CCDCOE

*By Ivan Christian, Research Assistant and Siddhant Shrivastava, Research Associate, iTrust*

In early June, an iTrust delegation led by Centre Director Prof Aditya Mathur headed to Tallinn, Estonia to attend the 14th International Conference on Cyber Conflict (CyCon) as a Gold Sponsor as well as speaker at the conference.

CyCon is a cyber security conference that was started as a multidisciplinary conference for technical, legal, policy, strategy, and military view on cyber security. It is also a platform for researchers and industry experts to showcase their research and progress in their respective fields.

As a Gold Sponsor, iTrust was able to set up a booth to showcase its technologies to a global audience. Ivan Christian introduced visitors to the Digital Twin - a virtual replica of the Secure Water Treatment (SWaT) testbed - that can be used as a remote training, education and cyber exercise platform (see next page). Indeed, the Digital Twin has been used by NATO CCDCOE in two iterations of its annual Locked Shields exercise in 2021 and 2022.

As part of the Digital Twin presentation, iTrust researcher Ivan Christian - who has been instrumental in assisting Prof Mathur with finetuning the Digital Twin - also showcased anomaly detectors developed in iTrust.



**Fig 3: Prof Aditya Mathur (fourth from left) with Ministry of Defence, Singapore and iTrust members at the Gold Sponsor booth**

He showed visitors how AICrit, a data-based detector, and DAD, a design-based detector, were able to detect the majority of simulated direct OT attacks launched on the Digital Twin, thereby showing its usefulness in training, cyber drills and education (see also next article.)

As a Gold Sponsor, iTrust was given a speaking slot for Prof Mathur to discuss the fusing of artificial intelligence and a design-centric approach towards the cyber defence of critical infrastructures.



*Fig 4: Prof Aditya Mathur speaking at CyCon*

In addition to this, iTrust also had a conference paper accepted at CyCon. In this paper by Siddhant Shrivastava, Francisco Furtado, Prof Aditya Mathur and Mark Goh, Siddhant shared the lessons distilled from iTrust's experience in conducting international cyber exercises over the past 6 years. He also suggested ways to design better cyber exercises to form the next wave of coordination and cooperation among governments, industry and academia to strengthen our collective defenses against these new domains of warfare and conflict. One set of tools that have proved very valuable in such cyber exercises is the Twin.

A significant amount of interest was generated at the end of the presentation and the showcase.

Visitors were interested in using our technologies for their own exercises and training as it was something novel and unique that no other labs or institution currently provides.



*Fig 5: Siddhant Shrivastava at the panel discussion following his presentation*

## SWaT Digital Twin

### Twin used twice for teaching

*By Asst Prof Sridhar Adepu, Bristol University and Mohammed Meran, Senior Research Assistant, iTrust*

For two months, the SWaT Digital Twin was used our group of 19 students from SUTD's Master of Science Security by Design (MSSD) programme to launch attacks and implement detectors as part of their CPS course project. Likewise, it is also being accessed remotely by researchers and PhD students from the University of Bristol for research, led by Asst Prof Sridhar Adepu, who had developed an invariants-based anomaly detector for SWaT while he was a researcher with iTrust.

The Twin serves as a teaching and training tool for students before they advance to the physical testbed in their experiments. Thanks to the twin's intuitive interface, the students could understand and explore each of SWaT's six PLC (programmable logic controllers) functions work and the correlation between actuators and sensor values. The Twin is coupled with an Attack Desk - an innovative tool with a library of cyber attacks - that the students could use to launch simulated cyber attack and witness the effects of those attacks on the twin. Lastly, anomaly detectors developed by iTrust researchers that are installed in the Twin help the students to appreciate how design and machine learning can help to defend a critical infrastructure against extreme cyber attacks that lead to service disruption.

# SWaT

# Digital Twin

**i** The SWaT Digital Twin (DT) is a **high fidelity simulation** of an industrial-grade six-stage secure water treatment (SWaT) plant in iTrust



Interfaces with **anomaly detectors** that generate alerts and point to specific plant components where there is a process anomaly



Interfaces with **OTVision** to provide real-time view into evolution of the state of each of the 45+ components in DT



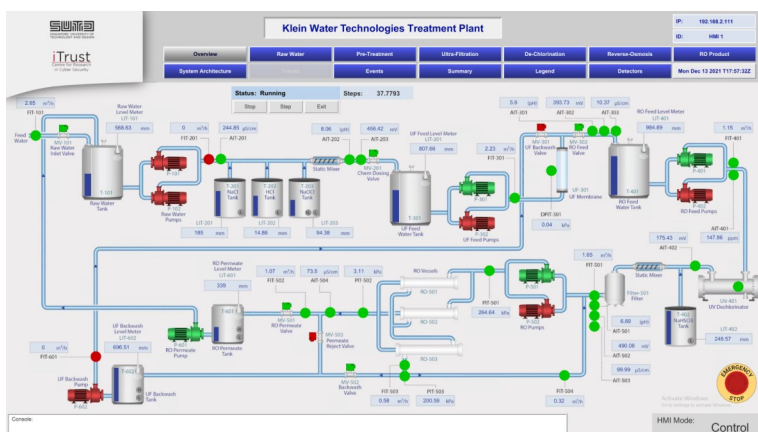
Interfaces with **Attack Desk** to design, save and launch cyber attacks on the DT in real time



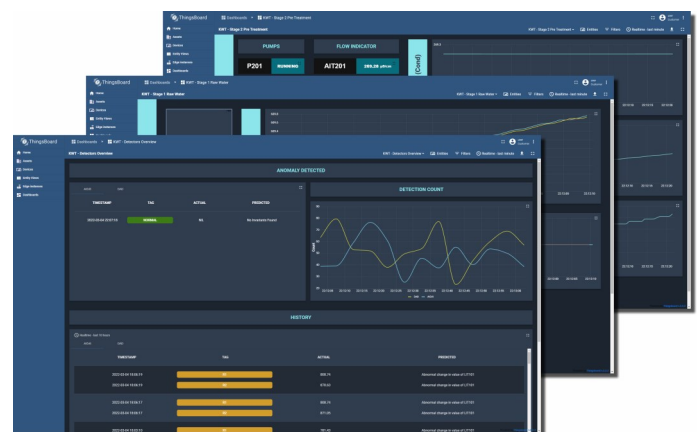
**Remote access** to DT is available to meet an organization's cybersecurity needs (training, education, cyber drills etc.)



DT is being used for **cyber exercises (e.g. Locked Shields)**, R&D, education & training



SWaT Digital Twin SCADA



OTVision

# International Maritime and Port Technology and Development Conference

## iTrust shares its guidelines on shipboard cyber risk management at an international forum

At the International Maritime and Port Technology and Development Conference (MTEC) in Apr 2022, Research Assistant Priyanga Rajaram presented her team's efforts in developing a set of guidelines towards the cyber risk assessment of shipboard OT systems. Along with the guidelines, a checklist for ship inspectors and ship owners to conduct their own cyber hygiene were the fruits of a year-and-a-half long study led by iTrust Co-centre Director Prof Jianying Zhou.

MTEC is one of the key maritime technology events during Singapore Maritime Week 2022. The annual MTEC is jointly organised by the Maritime and Port Authority of Singapore (MPA) and The Research Council of Norway (RCN), in partnership with Singapore Maritime Institute (SMI) and SINTEF Ocean.

## Engagement with Maritime Industry

### iTrust engages with French shipping giant CMA CGM

*Reproduced from LinkedIn post by the Executive Director of the Singapore Maritime Institute*

Executive Director of the Singapore Maritime Institute (SMI), Mr Cheng Peng Tan and the Maritime and Port Authority of Singapore (MPA) Director (Innovation, Technology and Talent Development), Mr Yi Han Ng, hosted a delegation from CMA CGM on 20 May 2022 to explore collaboration opportunities between CMA CGA and our R&D partners from the local institutes of higher learning. The delegation comprised Mr Xavier Leclercq, Vice President; Ms Karine Desrues, Vice President, R&D Group; Mr Julien Lorida, Deputy Vice President and Mr Francois-Xavier Accard, Managing Director.

SMI outlined the broader maritime R&D and innovation ecosystem, including SMI's Centres of Excellence. SMI



**Fig 6: Mr Tan Cheng Peng, ED, SMI with Mr Francois-Xavier Accard, Managing Director, CMA CGM (Photo credit: SMI)**

also shared its key thrusts, R&D and International plans with the meeting to establish Singapore as a global maritime knowledge and innovation hub over the next 10 years. Dr Kenneth LOW from the Singapore Institute of Technology presented its Future Ships and Systems Design programme while Mr Mark Goh from iTrust took the opportunity to share its new Maritime Testbed of Shipboard OT Systems for Cybersecurity Research, Training, Exercise and Education (MariOT). Prof Allan Magee gave an overview of the R&D capabilities at SMI's Centre of Excellence for Autonomous & Remotely-Operated Vessels.

CMA CGM was impressed with the scale and relevance of the R&D areas and programmes and expressed interest to explore further. SMI and its partners also look forward to potential collaboration opportunities with CMA CGM's Group.

## OT Cybersecurity Training

### Trained to protect

iTrust research staff conducted a 3-day OT cybersecurity course in May 2022 for 11 participants from GovTech and DSO. The course was led by iTrust Cyber Tech Lead Francisco Furtado and co-trainers Siddhant Shrivastava and Ivan Christian and iTrust engineers Andrew Tay and Tay Boon Kiat.

The curriculum was especially curated for the participants and comprised the following topics:

- OT fundamentals
- OT attack scenarios
- Data extraction

- Types of anomaly detection
- Framework to design their own attacks and pit them against iTrust's anomaly detectors

On the training, one participant remarked that the “PCAP analysis was the most useful as it gave us a better understanding on how the various ICS/OT protocols work under the hood and how to identify them.” In addition to having the opportunity to design attacks, another participant felt that it “...was most useful to be able to experience the receiving end of ICS attacks as the defender.” A third added that the hands-on nature of the training allowed participants “...to see impact(s) on (the) real testbed.”



*Fig 7: Trainees from GovTech with their trainers (front row from left: Siddhant Shrivastava, Francisco Furtado; second row from left: Ivan Christian)*

Visits

## Ministry of Economic Affairs and Communications of Estonia

At the invitation of the Infocomm Media Development Authority of Singapore, Mr Andres Sutt, Minister of Entrepreneurship and IT of the Ministry of Economic Affairs and Communications of Estonia of Estonia, who was in Singapore to participate in the Asia Tech X Singapore Summit, visited iTrust on 1 June 2022. He was hosted by iTrust Co-centre Director Prof Jianying Zhou. An old friend of iTrust, Mr Raimo Peterson, was also present during the visit!



*Fig 8: Prof Zhou (right) explaining the SWaT processes to (from left) Mr Raimo Peterson, Minister Andres Sutt and Mr Helmuth Martin Reisner*

## Purdue University

SUTD's Senior Director of Office of Marketing & Communications, Ms Corinna Choong hosted a group of students from Purdue University. The students were led by Prof Samuel Labi, Professor of Civil Engineering, Purdue University under the Purdue Study Abroad Programme. The visitors were given a tour of SUTD's facilities, including iTrust's testbeds.



*Fig 9: Visitors from Purdue University were hosted by Ms Corinna Choong, Senior Director, Office of Marketing & Communications*

iTrust Matters

Jillian Chin graduated from the National University of Singapore (NUS) with a B.Eng in Chemical Engineering. She also holds post-diploma qualifications specialising in Human Resource (HR) as well as in finance and accounting.



Prior to joining iTrust, she worked in an industry association supporting the national standardisation

programme and in a start-up company where she managed all administrative-related matters. Jillian enjoys meeting and interacting with people from different walks of life. Her interest to understand various cultures has led her to taking up different languages such as Japanese and Spanish.



iTrust is now on LinkedIn — connect with us! Feel free to reach out to us to explore research

collaborations, testbed usage and training and testing services. Email addresses end with the domain [@sutd.edu.sg](mailto:@sutd.edu.sg)

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