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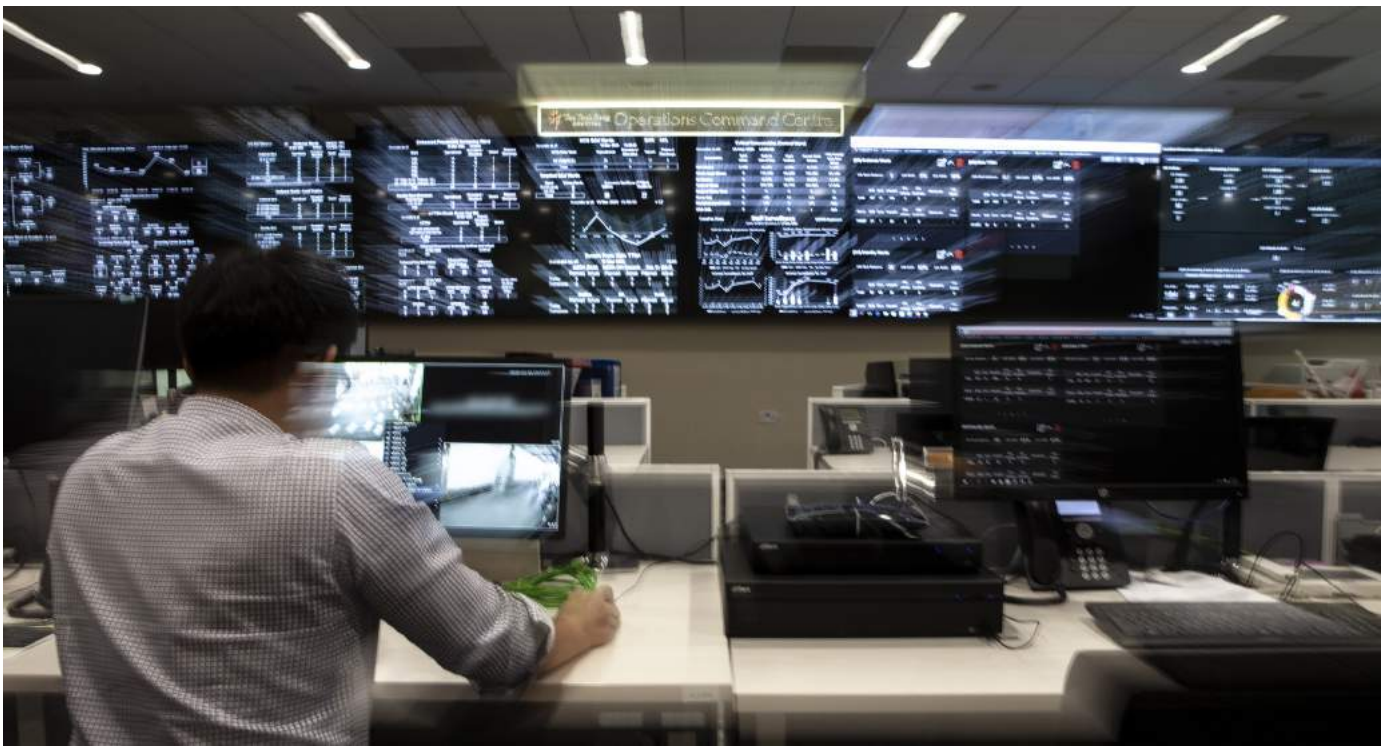
Cover Story:

COVID-19 Care Continuum

Smart Hospital for the Future

PLAY VIDEO

Summary: Tan Tock Seng Hospital, a large multi-disciplinary public hospital in Singapore enters into the future of Hospital Operations with Command, Control & Communications (C3) capabilitites at its new Integrated Operations Command Centre.



On 22 Jan 2020, Singapore raised its Disease Outbreak Response System Condition (DORSCON) (Singapore Government 2020) level from green to yellow, in the face of the increasing number of novel coronavirus (COVID-19) cases linked to China. Two weeks later on 7 Feb 2020, it was raised to orange, the second highest level of alert on the back of a few local cases without any links to previous cases or travel history to mainland China.

Tan Tock Seng Hospital (TTSH) was at the epicentre of Singapore's outbreak response to COVID-19. It was back in 2003 that the hospital was also designated the SARS hospital in Singapore then. Lessons were learnt from SARS in 2003 and H1N1 in 2009 and these lessons helped us to develop a state-of-the-art 330-bed facility for Infectious Diseases – the National Centre for Infectious Diseases (NCID). NCID was officially opened in September 2019 to always be prepared for a containment strategy in the event of another outbreak. The plan was for the main hospital to support and augment NCID with manpower and resources, and transfer existing patients back to the main hospital to free up capacity for outbreak response. This was to be tested for the first time during this outbreak.

In about a week from activation, TTSH scaled up operations to open a large 24/7 screening centre that can see 200 patients at any one time, and support the manning and opening of 200 Negative Pressure Isolation beds for outbreak purposes at NCID. This was scaled up to the full 586 beds with contingency plans ready for beyond 586 beds. This was a massive undertaking for the hospital that operated at 90-95% Bed Occupancy Rate during Business-As-Usual (BAU). BAU ambulatory services had to be scaled down to less than 50% to free up manpower for deployment to fill three shifts at the NCID. Services such as Laboratory had to operate rapid round-the-clock testing and

the Hospital's Clinical Epidemiology team conducted intensive surveillance in terms of contact tracing and activity mapping for patients, and sickness surveillance and twice-daily temperature monitoring for all staff. Staff from various departments were mobilised, mask-fitted and trained to assume their outbreak roles. Critical supplies for the outbreak were reviewed based on new norms of higher burn-rate and for longer term continuity. In addition to the outbreak response at NCID, the hospital conducts enhanced pneumonia screening for local surveillance, and all patients with pneumonia are isolated at the main hospital until tested negative twice over 24 hours.

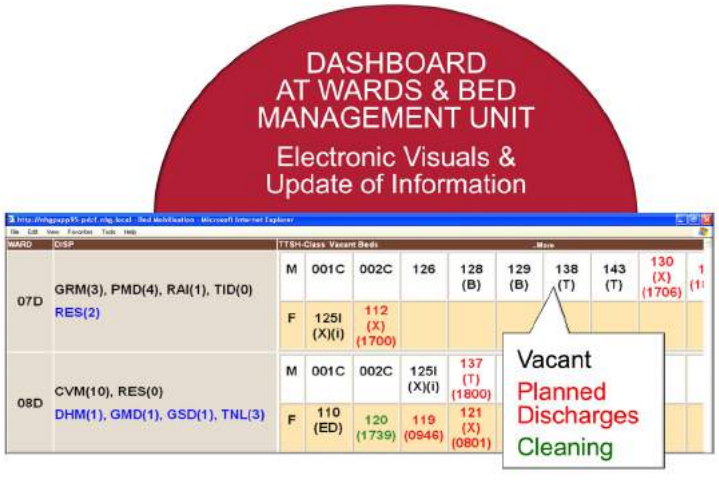
More than two months into DORSCON orange, Singapore has gone into "Circuit Breaker" mode to have our residents stay at home, our schools to use home-based learning and our non-essential workplaces to close with work from home options. The number of COVID-19 cases has increased and community isolation facilities have opened to converse healthcare capacity for those who need acute and intensive care. It is a critical time for us to contain the outbreak and to sustain our healthcare workforce and capacity. TTSH and NCID attends to 70% of the confirmed and suspect cases of COVID-19 in Singapore. Local GPs and Polyclinics screen for suspect cases and refer them to NCID and other public hospitals for confirmation and containment. To date at TTSH and NCID, we have screened more than 18,000 persons and admitted more than 3000 patients for confirmation and containment. At the same time, we continue to operate our Emergency Department (Singapore's busiest) and our Business-As-Usual wards at 70-80% bed occupancy rate. With the likelihood of a more prolonged outbreak, we are looking beyond surge to sustainability and optimising our schedules and processes to enable better resource management and efficiency, allowing staff sufficient rest for the journey ahead.

One important strategic advantage that the hospital has to manage our crisis response to the COVID-19 outbreak is our integrated systems approach to Hospital Operations. The recently-opened TTSH Operations Command Centre (OCC) featured our new Command, Control and Communications (C3) system that went live in December 2019. It provides real-time visibility, flow management and resource optimisation to enable Hospital Management to coordinate, and make timely and effective decisions. However, given the multiple and evolving changes in workflows during an outbreak, the C3 system needed to be reconfigured for an outbreak scenario.

Taking Command of the Hospital's COVID-19 Outbreak Response

We were in the midst of developing the Outbreak Scenario for C3 when COVID-19 struck. There is no better time to accelerate the development of our C3 Capabilities for an Outbreak Scenario than during an outbreak itself. Adapting the system quickly for our outbreak response workflows, C3 has given us a strategic advantage in communicating and coordinating our responses across our hospital. The key success factor in our outbreak responses lie in our ability to communicate and coordinate hospital-wide operations, based on reliable and timely data from across multiple systems and the frontline. Reporting is also streamlined to prevent confusion and disruption to frontline operations. The system provides for visibility on frontline operations and prompts hospital management on key decisions in the ramp up of our outbreak response including deploying manpower, ensuring critical supplies, and facilitating the opening and capacity management of our screening centre and outbreak wards at NCID. As an integrated operations command centre for TTSH and NCID, it also allows the coordination between our BAU and Outbreak responses that need to work hand-in-hand for an integrated response.

With our newly commissioned Real-Time Location System (RTLS) for tracking patients and staff at NCID, live video streaming and analytics from key ground operations



across our hospital, and the real time clinical surveillance data, we are able to coordinate and respond more effectively across our hospital. These capabilities when fully developed and integrated with C3 can enable better and timely decision making to aid our response, and free up frontline staff from manual reporting when they are already busy caring for our patients. We are still in rapid agile development to learn as much as possible during this outbreak. There is no crisis to waste. It is important we learn as we do, and not just learn after it is done.

Driving Systems Innovation in Hospital Operations

Even without disease outbreaks, healthcare delivery has been increasing in complexity as there are many different parts in our care delivery system to coordinate and integrate for a smooth patient journey throughout our hospital, from admission to discharge. The journey towards an integrated Operations Command Centre did not happen overnight for us. With continuously improving our processes, stacking up new technologies and redesigning our workforce, we had taken a deliberate and systems-based approach to innovating our hospital's operations, while building a collaborative culture across our clinical and operations staff.

More than 10 years ago, we embarked on a determined journey to better strategise and manage TTSH's regularly high bed occupancy. We had avoided one-third of potential admissions by fast-tracking them for review at our outpatient clinics and day facilities, and shifted 70% of all surgeries to an ambulatory setting. Yet with 1700 beds across the hospital, we were full house more days than not with more than 85% of patients via our Emergency Department (ED). Back then, staff across the hospital were making multiple phone calls, filling out forms and charts just to assign a bed to a patient waiting at the ED. It was high time that we moved from this tedious and untenable "Pen, Paper, Phone" method of bed allocation, to one where processes are automated and optimised for patient care and bed utilisation. To do that, we needed real-time visibility to track where our resources and our patients are and their status.

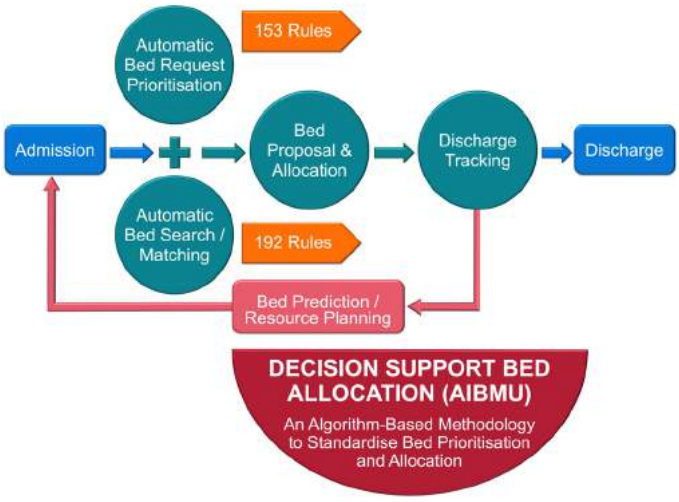
In 2008, we implemented a Real-Time RFID-Tagging System, which allows us to automate admission and discharge workflows, and identify the location of patients. This provided visibility of beds in our system. When a patient is admitted, he is tagged with an RFID tag and his information is actualised automatically on the ward's dashboard, replacing the old practice of manual and at time inaccurate updates of the ward census on a whiteboard. The system enables the location tracking of our patients even as they go for their tests, scans and procedures outside the ward. It greatly facilitates coordination and communication of the patient's location and progress between the care team and family members.

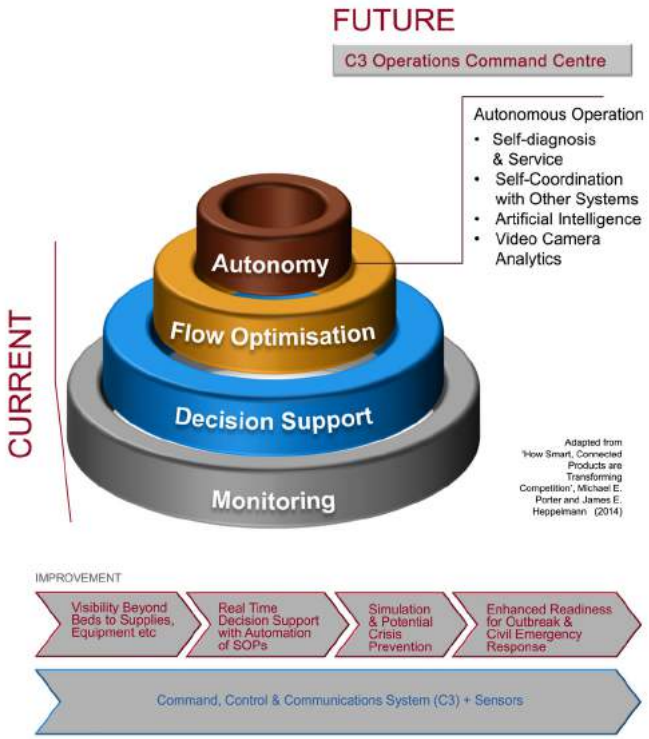
> There is no crisis to waste. It is important we learn as we do, and not just learn after it is done

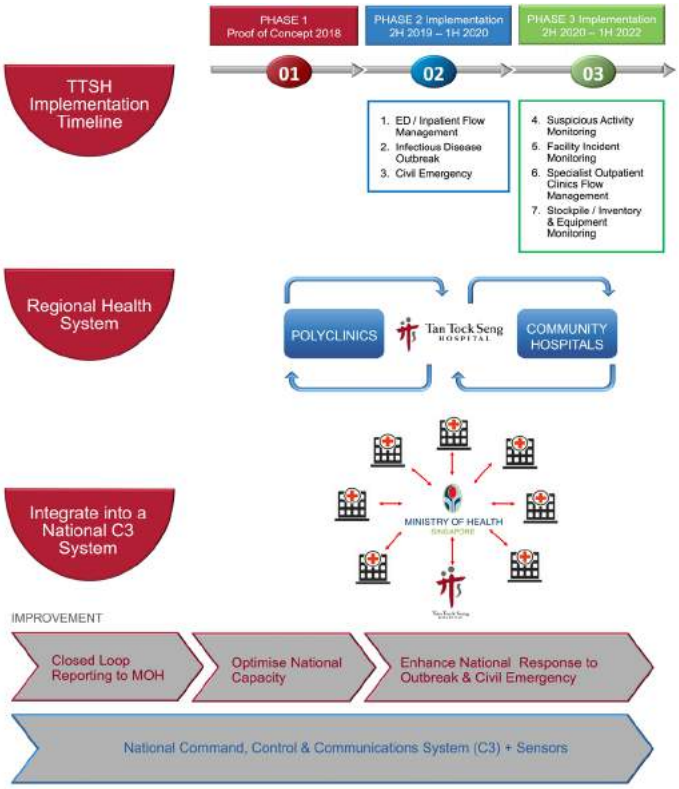
When a patient is discharged, the removal of his RFID tag automatically triggers the discharge processes including notifications to business office and housekeeping. A countdown timer set for 30 minutes is activated for housekeeping to completely turn around the beds and for OCC to assign the bed to the next patient waiting at our ED. We now have full real-time visibility of patients and beds in the system – their location and their status.

In 2011, we developed and introduced the Artificial Intelligence Bed Management System (AIBMU) to provide rule-based decision support on bed allocation based on priority and matching. There are 345 rules to prioritise and match patients to beds, which make the task of assigning beds beyond the ability of the human mind. Prioritisation rules were based on clinical triaging guidelines, established in consultation with clinicians, while matching rules take into account factors such as class of wards, gender, and specialty requirements to ensure operational efficiency. As a result, our AIBMU calculates and allocates the best available bed options in order to best match the patient's requirements and to ensure clinical prioritisation for urgent cases.

Nursing also introduced the Electronic Discharge Tracking System (eDTS) that optimises discharge planning with an estimated discharge date (EDD) and time. This allows us to predict the availability of beds coming online and for







the AIBMU to allocate an upcoming bed that will be available soon in the system that better matches the patient's requirements, reducing the rework of internal bed transfers later. From an army of staff managing beds, we now need only 2-3 administrative staff per shift to meet the bed allocation needs of a large hospital like TTSH with 1700 beds and growing.

As innovative as the AIBMU was in 2011 in changing the way we manage bed operations, in 2014 we started visioning something more transformative; work began on conceptualising a full Command, Control & Communications (C3) system that enables real-time hospital operations beyond bed management.

In May 2019, we unveiled our new TTSH OCC and soon after, its state-of-the-art C3 Smart Hospital System at our Ng Teng Fong Centre for Healthcare Innovation. Our OCC now functions much like an airport control tower, operating 24/7 to ensure efficient, safe and effective operations during peacetime and crisis. The C3 Smart Hospital System supports daily operations from the ED to inpatient wards to discharges, across the main hospital, NCID and the soon-to-be-up 600-bed Integrated Care Hub for rehabilitation and subacute care.

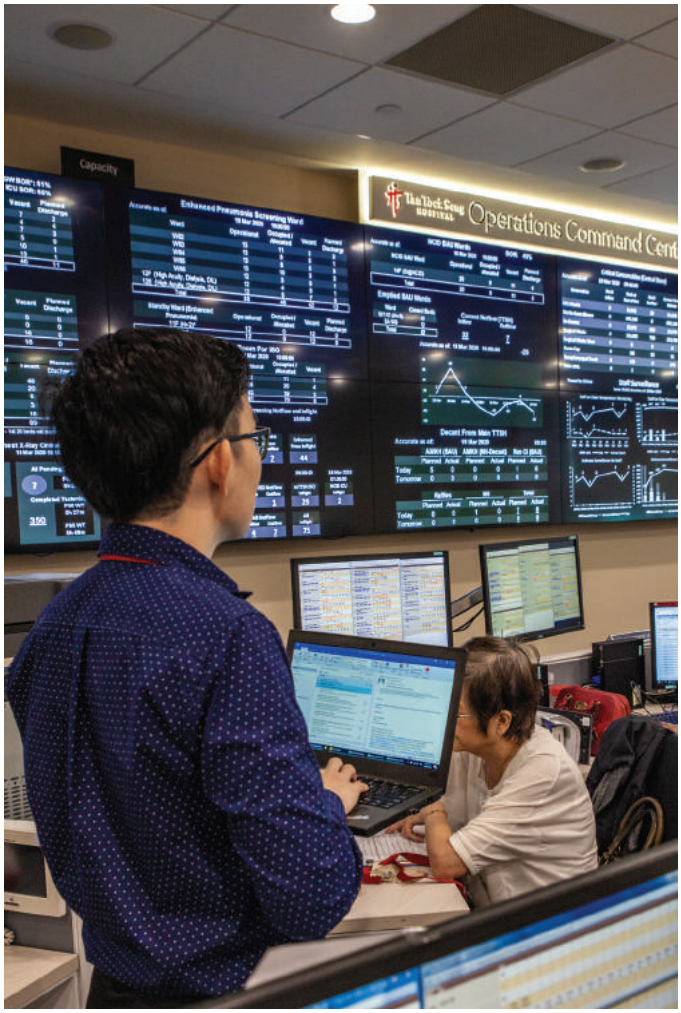
As the "brain" of our hospital, C3 is a smart system of systems that can sense, think and respond to optimise patient flow and care delivery. It enables a mind-set shift in hospital operations from resource management to flow optimisation to autonomous orchestration. Hospital data from across various source systems is pulled into a flow concept that highlights choke-points within the hospital and triggers standard operating procedures to respond to various incidents and situations. From fragmented operations, we now have the C3 capabilities to enable our hospital to run as a coordinated system to ensure better overall care experience for our patients. Over time, C3 will also incorporate machine learning and predictive analytics to ensure better prospective actions and forward planning rather than taking reactive measures.

Our C3 Smart Hospital System is developed by TTSH, Integrated Health Information Systems (IHIS), Singapore Technologies Engineering Electronics (STEE) and supported by the Ministry of Health (MOH), Singapore. C3 is set to change the way hospitals are run. This is a first for Singapore's healthcare and possibly leading the world in hospital operations.

In the Pipeline for C3

Soon, we will introduce more sensors on the ground and digitalise manual processes to feed operational data to C3. More than just enabling awareness, there is a concurrent need to make sense of what we see on the ground as well. With better awareness of the ground situation and more information at hand, we can then make better decisions together.

Artificial Intelligence can also be built into the C3 system to make certain decisions autonomously. What we aim to do is to at least have 80% of operational responses automated, leaving about 20% of more complex situations for staff to review and address with real-time decision support



by the C3 system.

The C3 Smart Hospital System is scalable across our healthcare system. Plans are in the pipeline to extend C3 capabilities upstream to join up the pre-hospital phase (ambulances) and downstream to Community Hospitals. This will facilitate care transitions and enable more seamless and timely patient care. C3 capabilities will be extended to MOH and other hospitals to enable our public healthcare system to load balance and optimise patient care and national bed utilisation.

The C3 Smart Hospital System is also stackable to expand its functionalities to other operational scenarios. Following the current C3 deployment for daily inpatient operations, other scenarios in the pipeline include outbreak management, supply chain management and critical equipment management.

Increasing Human Touch with Digitalisation

C3 is an exciting digital transformation of our hospital operations. Yet, our digital transformation has less to do with new technologies and more to do with our people. Better technologies should lead to better jobs, and in turn better value for our patients. We need to innovate innovation itself to enable transformation in the digital age. At TTSH, we adopt a systems approach to Healthcare Innovation called our Innovation Cycle. Every Innovation starts by redesigning our care and processes; then leveraging technologies to enable our care or process; and finally redesigning our jobs to focus on what our patients value.

This cycle is iterative and enables innovation to scale, spread and sustain.

Digitalisation in healthcare is about returning meaning to our workforce to find joy at work. Today, our nurses spend about 70-90% of their time in managing the ward processes and paperwork from admission to discharge. Better technologies like C3 can free them up from administrative tasks, and they will have better jobs and spend more time with patients. Digitalisation leads to more human touch, keeping complexity at the back and humans at the front. If we can reduce mundane and repetitive tasks, it will mean better decision support for our staff, better care experience for our patients, and more time to engage patients in their health and recovery.

With C3, the exciting future of hospital operations is beckoning. ■

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Key Points

- TTSH was at the epicentre of Singapore's outbreak response to COVID-19.
- COVID-19 was the first test of capacity for outbreak response.
- The new C3 system provides real-time visibility, flow management and resource optimisation for better management decisions.
- Healthcare crises are a valuable opportunity for learning on the spot.
- C3 frees nursing staff from administrative tasks so they can spend more time with patients.

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