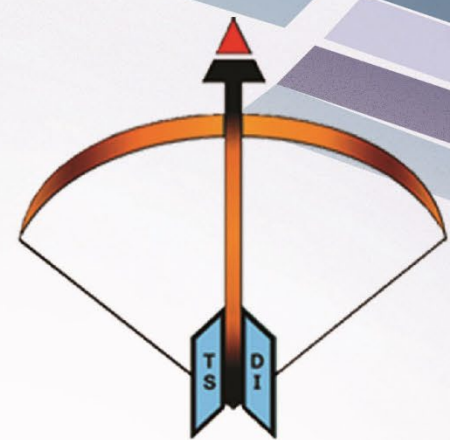




Temasek Defence Systems Institute

# Temasek Defence Systems Institute

## Integration of 5G Communications for UAV Control in a Multi-Link Network

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### Background:

- The advantages of 5G are ultra-low latency, high bandwidth, and the ability to support a massive number of connected devices
- This offers significant potential for enhancing UAV operations which requires robust and reliable communication systems that can maintain seamless control and data transmission in complex, dynamic environments
- Adapted Network Architecture from previous student evaluating Data Distribution Service (DDS) performance of an unmanned system network

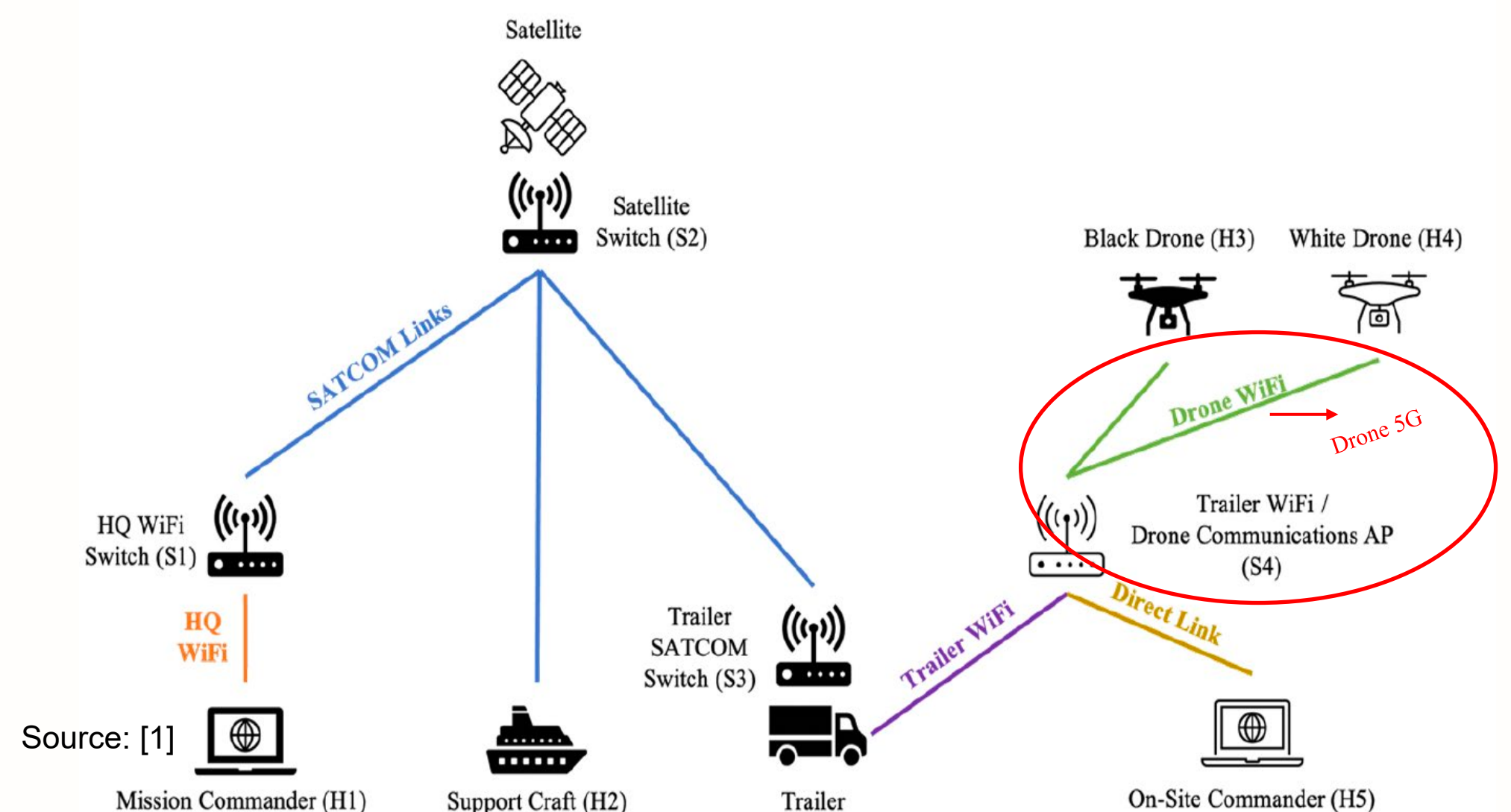
### Objectives:

- Explore the feasibility of integrating a 5G network for UAV control and sending of data to ground control station using a multi-link network architecture that incorporates DDS
- Evaluate the throughput and latency performance of the individual point-to-point links across various nodes, under ideal and jitter network configurations as well as multi-flow configuration
- Compare and analyze the network performance of the 5G network architecture against the network architecture of the earlier network

### Results and findings:

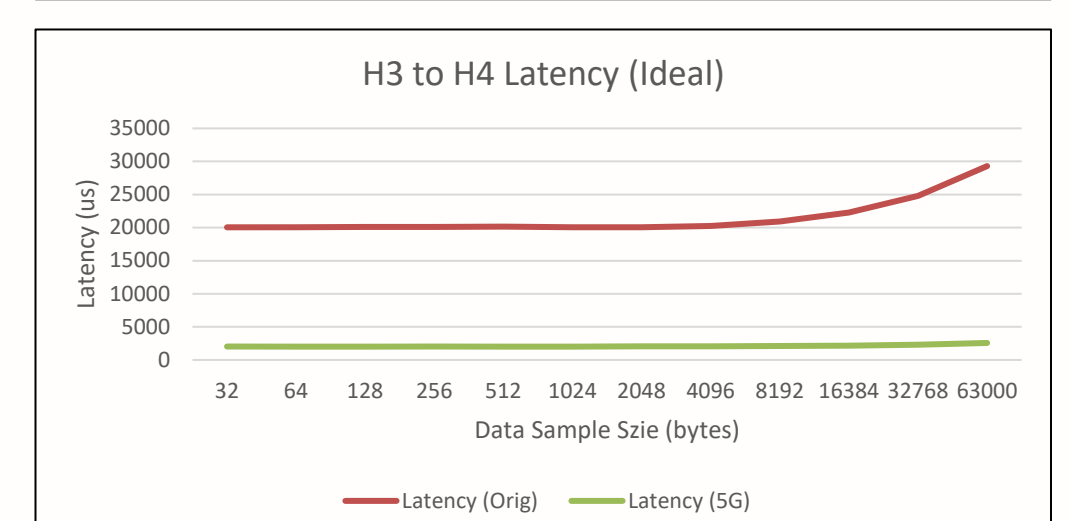
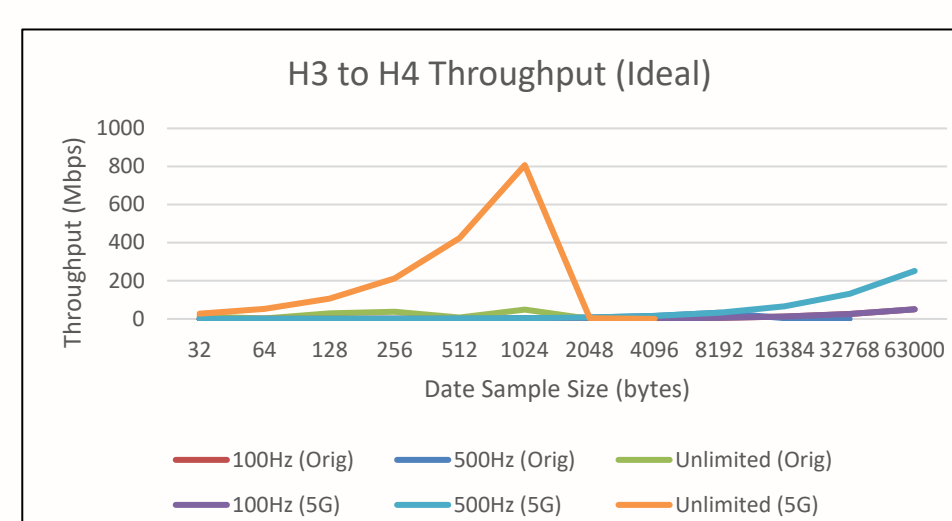
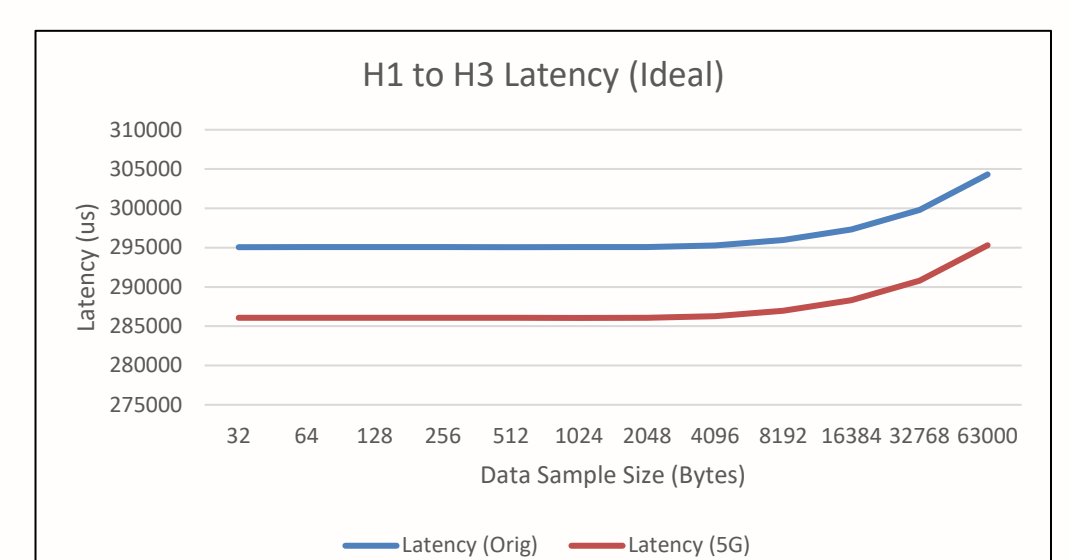
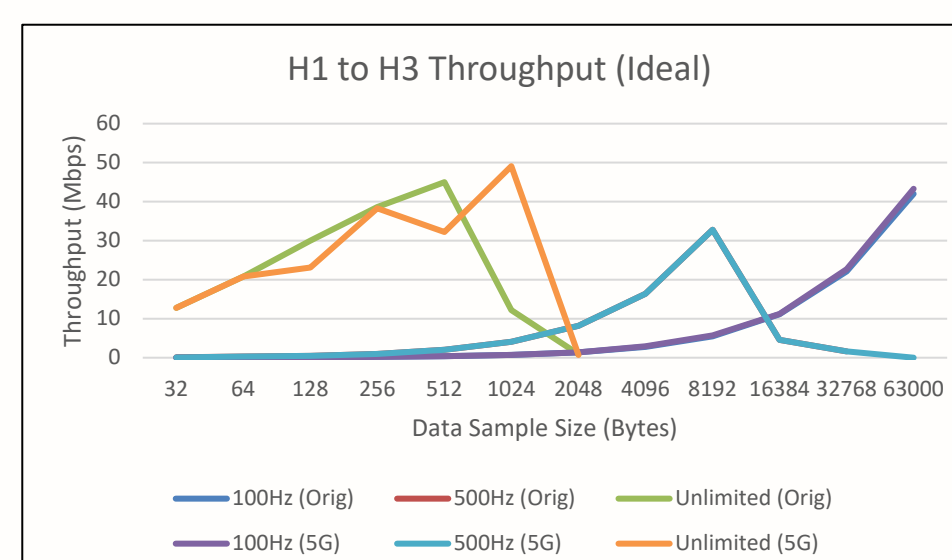
- For Ideal configuration, 5G technology demonstrated significant improvements in throughput and latency, particularly for links such as H3 to H4 and H4 to H5. Less evident gains for H1 to H3 links, where bottlenecks from legacy networks like WiFi and SATCOM limited the 5G benefits
- In the Jitter Configuration, 5G exhibited resilience by maintaining superior throughput and latency, even under jitter conditions, outperforming WiFi at higher publication rates
- In the Multi-Flow Configuration, although the overall throughput remained stable due to low data demands, 5G significantly reduced latency, highlighting its effectiveness in minimizing delays even under modest network usage

### Network Architecture:



### Simulation Configurations and Scenario:

| Configurations | Node (Pub) | Node (Sub) | Test Modes | Scenarios                             |
|----------------|------------|------------|------------|---------------------------------------|
| Ideal          | H1         | H3         | Throughput | PubRate at 100Hz, 500Hz and Unlimited |
|                | H3         | H4         | Latency    |                                       |
|                | H4         | H5         | Throughput |                                       |
| Jitter         | H1         | H3         | Latency    |                                       |
|                | H3         | H4         | Throughput |                                       |
|                | H4         | H5         | Latency    |                                       |
| Multi-Flow     | H1         | H2         | Throughput | VoIP                                  |
|                | H1         | H5         | Latency    |                                       |
|                | H2         | H1         | Throughput |                                       |
|                | H2         | H5         | Latency    |                                       |
|                | H5         | H1         | Throughput |                                       |
|                | H5         | H1         | Latency    |                                       |
|                | H3         | H1         | Throughput | Video Comms                           |
|                | H4         | H5         | Latency    |                                       |
|                | H2         | H1         | Throughput |                                       |
|                | H3         | H1         | Latency    | Drone Telemetry                       |
|                | H4         | H5         | Throughput |                                       |
|                | H1         | H3         | Latency    |                                       |
|                | H5         | H4         | Throughput | Drone Control                         |
|                |            |            | Latency    |                                       |



### Future work:

- Vary sample sizes and PubRates in multi-flow configuration
- Increase scale of UAVs, work towards swarm UAVs operations
- Investigate cyber security measures and resilience of 5G networks

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