Distributed DCS/ICU Capacity in Island-Based Role 2 under Evacuation Delay
A Simulation Comparison of Centralized and Distributed Configurations

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1. Background
Island-Based Role 2 Differs from Land-Based Role 2

Land-based Role 2 often functions within a continuous evacuation chain.
In island operations, however, Role 2 may be physically separated from rear facilities and dependent on intermittent air or maritime evacuation windows.

Key Message:
Physical separation can transform Role 2 from an evacuation-chain link into a temporarily isolated surgical-critical care node.

2. Operational Problem
Evacuation Delay Converts ICU Turnover into the Bottleneck

- DCS requires postoperative ICU resuscitation.
- Evacuation delay prolongs ICU occupancy.
- ICU saturation can suspend new DCS despite available surgical teams.

Key Message:
Delayed evacuation shifts the bottleneck from operative throughput to postoperative ICU turnover.

3. Objective
Evaluate Centralized vs Distributed DCS/ICU Capacity

- Test whether evacuation delay makes ICU turnover the dominant bottleneck.
- Compare centralized vs distributed DCS/ICU configurations under identical total resources.
- Assess whether distributed DCS/ICU capacity preserves surgical continuity under localized evacuation delay.

Key Message:
This study tests DCS/ICU configuration, not full Role 2 duplication.

4. Simulation Model
DCS–ICU–Evacuation Flow Model

Figure 1. DCS-ICU-Evacuation Flow Model

Key Message:
The model tested whether evacuation delay converts ICU capacity into the dominant bottleneck.

5. Baseline Assumptions
Identical Total DCS/ICU Resources

- Same total surgical and ICU resources were used in both configurations.
- Distributed configuration separated only DCS and postoperative ICU capacity.
- Command, triage, ward, and support functions were assumed equivalent.

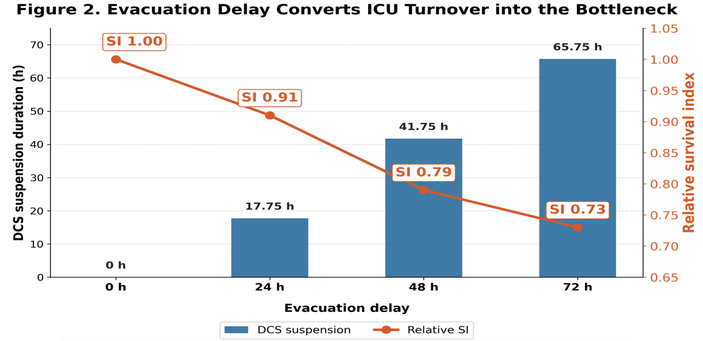
Configuration	DCS capacity	ICU capacity
Centralized DCS/ICU	2 teams × 1 node	6 beds × 1 node
Distributed DCS/ICU	1 team × 2 nodes	3 beds × 2 nodes

Parameter	Value
Casualty inflow	30 / 24 h
DCS demand	9 cases / 24 h
DCS duration	1 h / case
Surgical teams	2 total
ICU beds	6 total
Minimum ICU stabilization	8 h
Evacuation capacity	6 / day
Simulation horizon	96 h

Key Message:
Distributed configuration means redistribution of DCS/ICU capacity, not full Role 2 duplication.

6. Finding 1: Evacuation Delay Makes ICU Turnover the Bottleneck

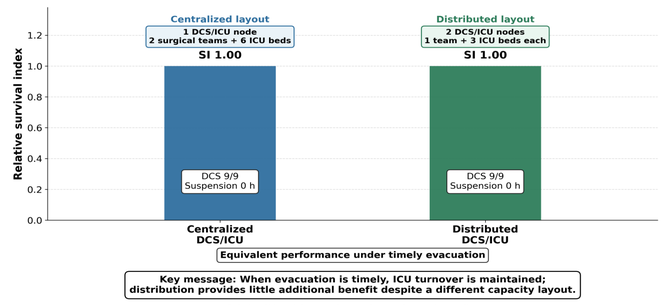
Figure 2. Evacuation Delay Converts ICU Turnover into the Bottleneck



Relative SI is a delay-penalty metric, not observed mortality.

7. Finding 2: Timely Evacuation: Configuration Has Little Impact

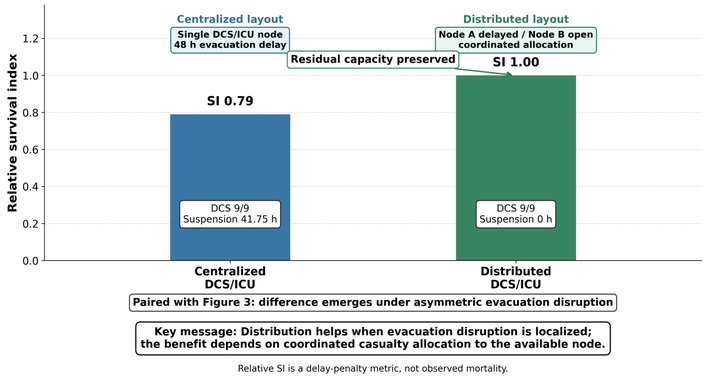
Figure 3. Timely Evacuation: Configuration Has Little Impact



Relative SI is a delay-penalty metric, not observed mortality.

8. Finding 3: Distributed DCS/ICU Capacity Preserves Continuity under Localized Evacuation Delay

Figure 4. Localized Delay: Distribution Preserves Residual Capacity



Relative SI is a delay-penalty metric, not observed mortality.

9. Interpretation
From Physical Separation to Resilience

- Delayed evacuation turns ICU turnover into the determinant of DCS continuity.
- Centralization improves pooling efficiency but creates a single bottleneck.
- Distribution sacrifices pooling efficiency but may preserve residual capacity under localized delay.
- Its value depends on asymmetric evacuation access and coordinated casualty allocation.

Key Message:
Distribution is a resilience strategy for asymmetric evacuation disruption, not a universally superior configuration.

10. Limitations and Future Directions
Toward Role 2-Level Prolonged Surgical-Critical Care

Limitations:
Conceptual simulation; patient heterogeneity, variable operative duration, non-DCS ICU demand, inter-node transfer, weather, threat exposure, evacuation routes, and logistics were simplified or not modeled. Relative SI was not observed mortality.

Future Directions:
Future models should incorporate probability-weighted evacuation delay, adaptive DCS/ICU node placement, and Role 2 endurance requirements for oxygen, ventilation, blood products, staffing, power/fuel, communication, and resupply.

Key Message:
Island-based Role 2 may require planned endurance capacity, not DCS throughput alone.

Conclusion

Evacuation delay can convert postoperative ICU turnover into the dominant bottleneck of island-based Role 2.

Distributed DCS/ICU capacity does not add resources and is not universally superior. Its value emerges when evacuation disruption is localized, residual node capacity remains usable, and casualty allocation is coordinated.

Island-based Role 2 requires design logic centered on evacuation uncertainty, ICU turnover, residual capacity, and planned endurance.

Declarations / Disclaimer
This study used a conceptual simulation model and did not involve human participants, patient data, or animal subjects. Ethics approval and informed consent were not required. The author declares no conflicts of interest and received no external funding. All simulation outputs were generated from predefined model assumptions. The views expressed are solely those of the author and do not necessarily represent the official policy or position of the Japan Ground Self-Defense Force, the Ministry of Defense, the Government of Japan, or any affiliated institution.