Multi-Rotor System Seminar 2025

Operation and Maintenance of Multi-Rotor Wind Turbines: Insights from a Case Study and a Startup Simulation Solution

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MRS 2025 Sponsored by:

Erneuerbare Energien Hamburg
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WIND CATCHING

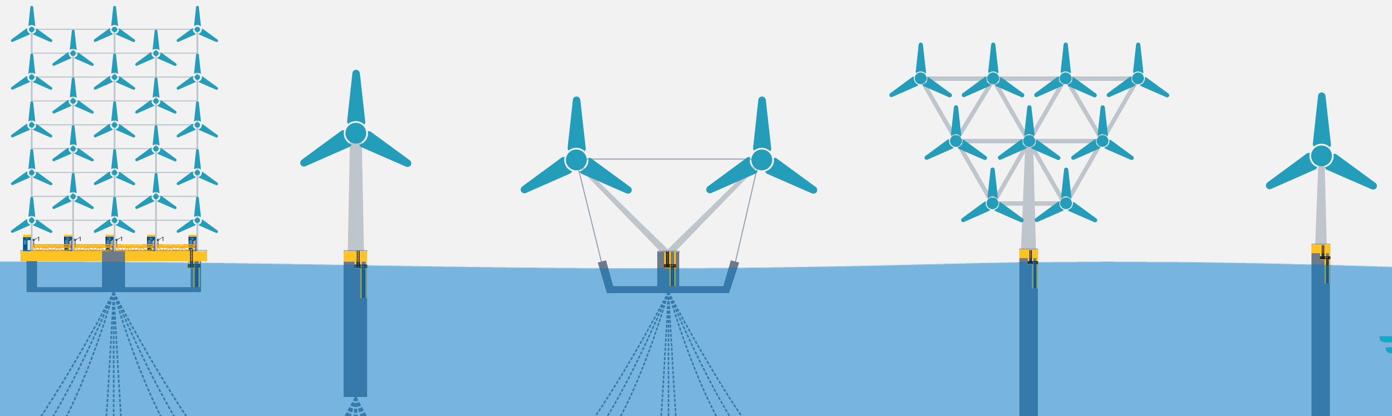
AGENDA

1 VENTARION

2 CASE STUDY

3 INSIGHTS

FOUNDED IN JULY 2025, VENTARION IS A STARTUP DEVELOPING AN INTELLIGENT SIMULATION PLATFORM FOR OPTIMIZING OFFSHORE WIND OPERATION AND MAINTENANCE FOR CONVENTIONAL AND NOVEL WIND TURBINES.



OPERATION AND MAINTENANCE COSTS ARE THE SILENT AND MASSIVE RISK IN OFFSHORE WIND. THEY CAN ACCOUNT FOR UP TO 30% OF TOTAL ENERGY GENERATION COSTS [1].

Operators still use limited models for lifetime O&M dynamic cost forecasts. → Compromising assumptions, unreliable cost forecasts, underestimated downtimes

Weather, logistics, asset aging, novel turbine specifications are not properly modeled. → Unrealistic costs, unplanned expenses, financial uncertainty.

No scalable, flexible and AI based intelligent solution exists today. → Risks remain high, leads to poor bankability and finally slower energy transition

FROM RISK TO PRECISION, WE MAKE OPERATION AND MAINTENANCE COSTS PREDICTABLE.

Three interconnected modules power one intelligent simulation platform, helping offshore operators see their true cost per MWh before it happens.

A Ventarion Sim

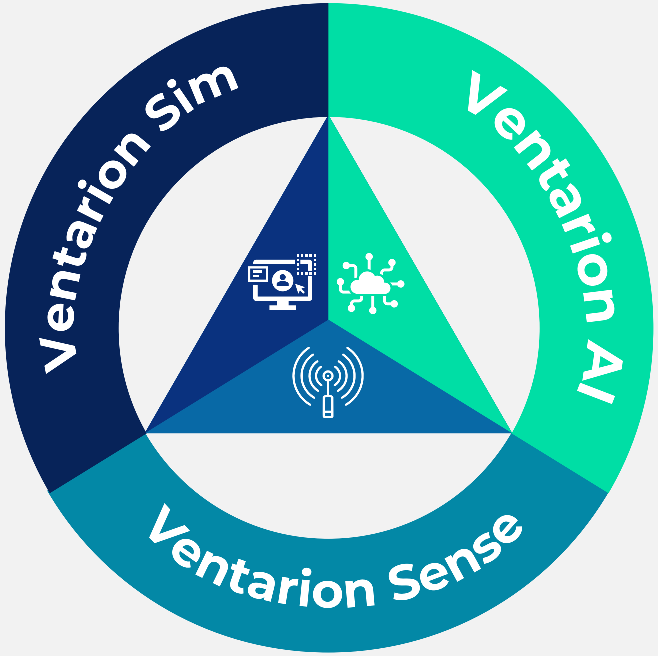
Dynamic 25+ year simulations with failure, repair, weather, and logistics modeling, tailored to different O&M strategies and various wind turbine types

B Ventarion AI

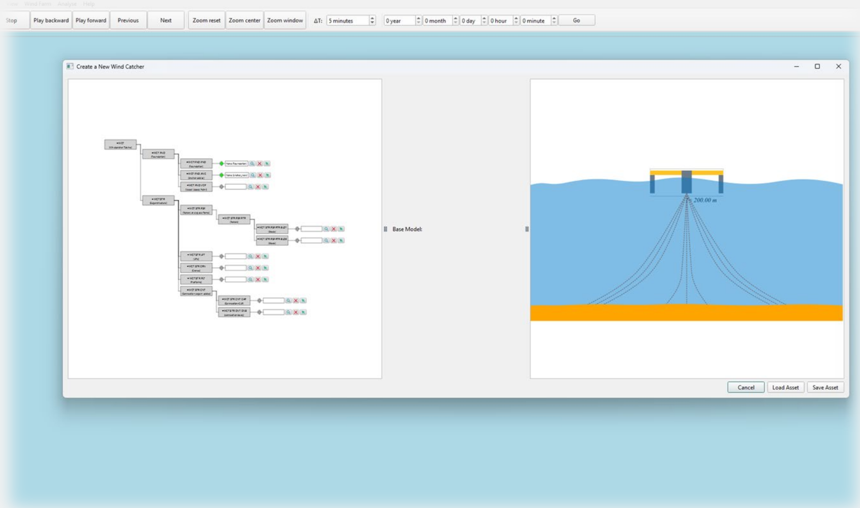
Interprets results, explains scenarios, and supports planning with human-readable insights. Real-time, tailored insights connected to the simulation models.

C Ventarion Sense

(Future integration) Hardware integration to bring real-time sensor data into simulation and enable predictive maintenance.

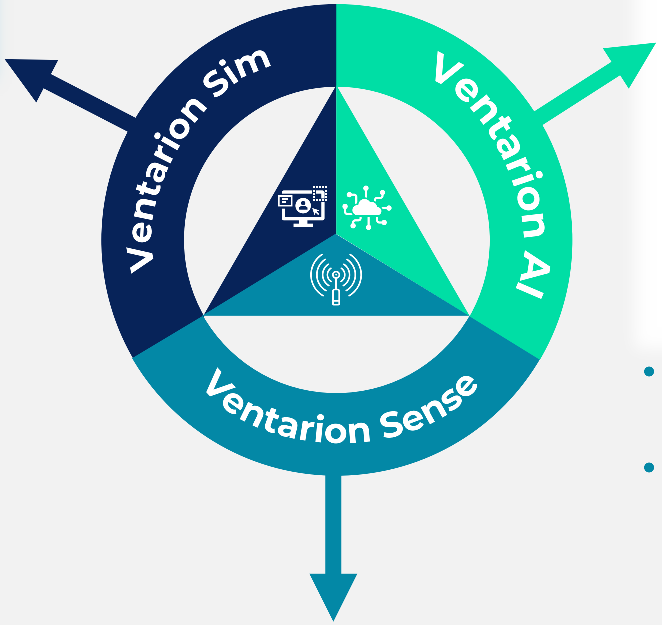


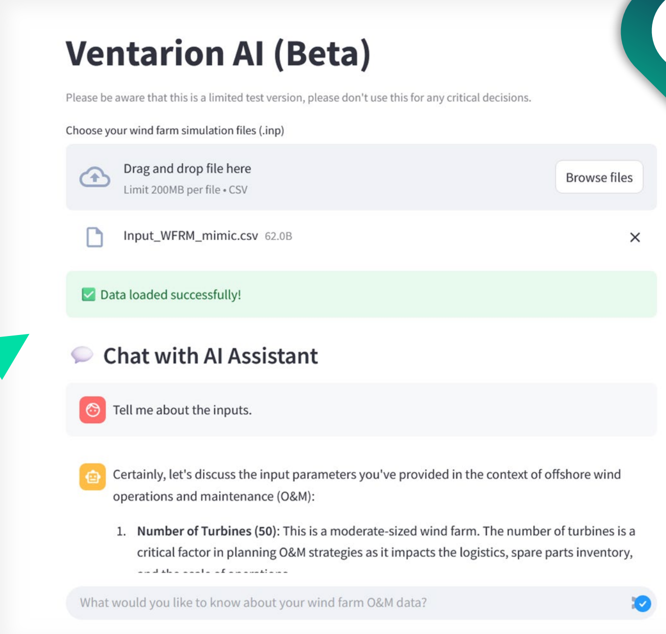
MINIMUM VIABLE PRODUCT



Ventarion Sim

- Business domain is hosted online.
- User interface is a desktop application.
- User interface developed using state of the art Qt Framework under LGPL license.





- Based on Mixtral 8x7B open source and open weight AI.
- Could be run completely offline.

Ventarion Sense

- Hardware integration phase will be developed through targeted prototyping and validation with early industry partners to ensure practicality and cost efficiency.

VENTARION WAS SELECTED TO POWER AN O&M STRESS TEST FOR WIND CATCHING SYSTEMS.

EnBW ⟷ WIND CATCHING

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HAW HAMBURG

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VENTARION

WE'RE LOOKING FOR STRATEGIC PARTNERS

OUR ASK

Offshore wind operators or OEMs interested in validating our O&M simulation platform in real-world projects (2025–2026)

Joint operation and maintenance simulation studies, stress tests tailored to novel or conventional wind turbine systems.

Early technical conversations that help us refine features, interfaces, and integration paths. Industry feedback.

CASE STUDY

STUDY AREA

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CASE STUDY

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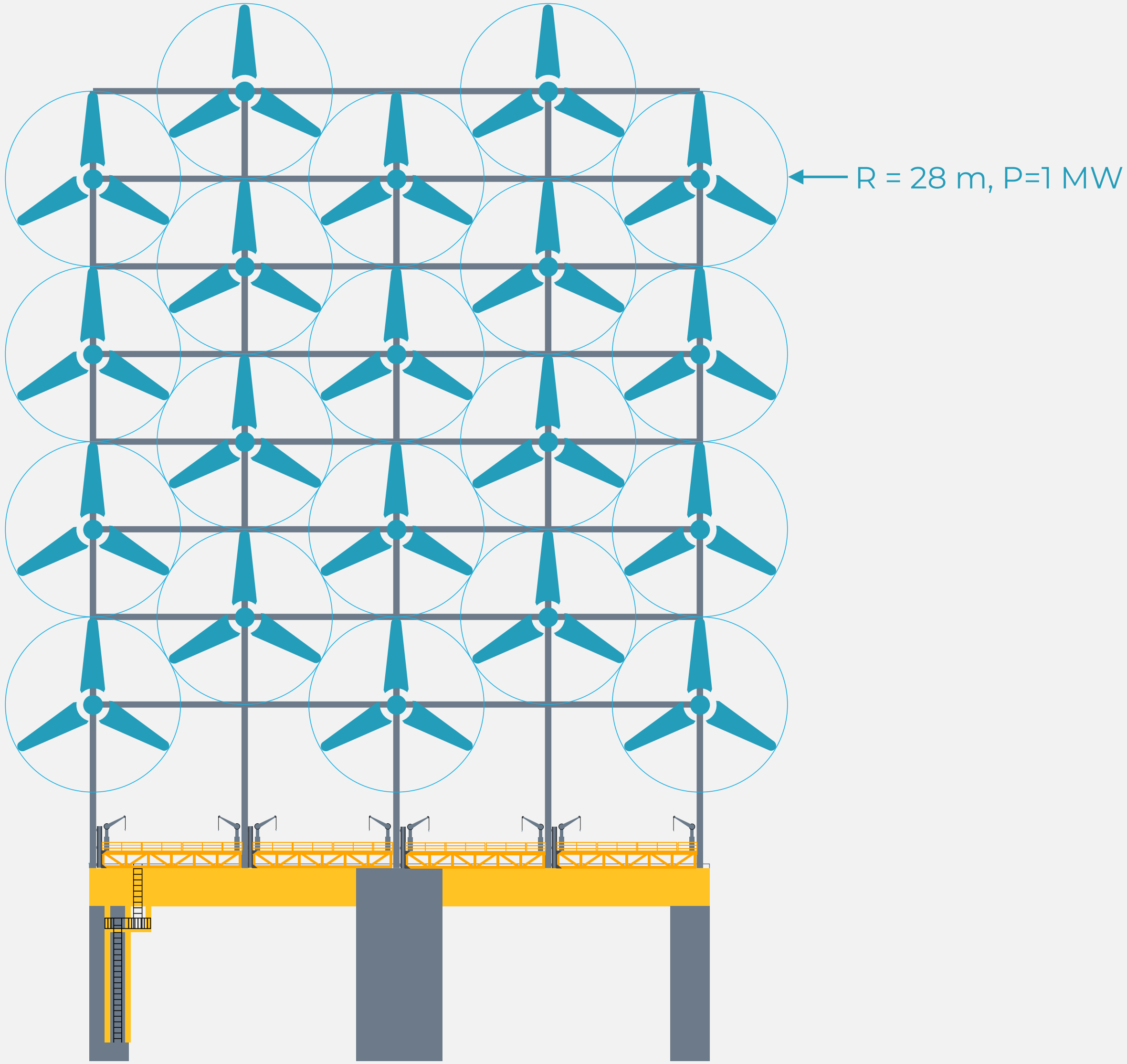
CASE STUDY

STUDY AREA


300 MW wind farm
Flensburg
Kiel
Neumünster
Lübeck
Cuxhaven
Bremerhaven
Hamburg
Aurich
Emden
Groningen
Oldenburg
Bremen
Lüneburg

THE 20 MW TURBINE



CASE STUDY

THE 1MW UNIT [2]

	Manual reset	Minor repair	Major repair	Major replacement
Failure rate [/turbine/year]	0.18	1.5	0.28	0.06
Repair Time [Hour]	1.50	3.0	26.0	54.0
Required Technicians	1	2	2	4
Failure costs [Euros]	0	300	2000	15000

SERVICE OPERATION VESSEL

CASE STUDY

Working Shift: 8:00 to 20:00

Mobilization time: 3 days (repeating)

Maximum offshore time: 4 weeks

Charter period: 25 years

SOV connection time: 15 minutes
SOV disconnection time: 10 minutes

Significant wave height limit: 2.5 m

Maximum workability wind speed limit: 15 m/s

https://www.4coffshore.com/vessels/vessel-esvagt-faraday-vid1615.html (Esvagt Faraday)

TECHNICIANS

Number of technicians: 20 people

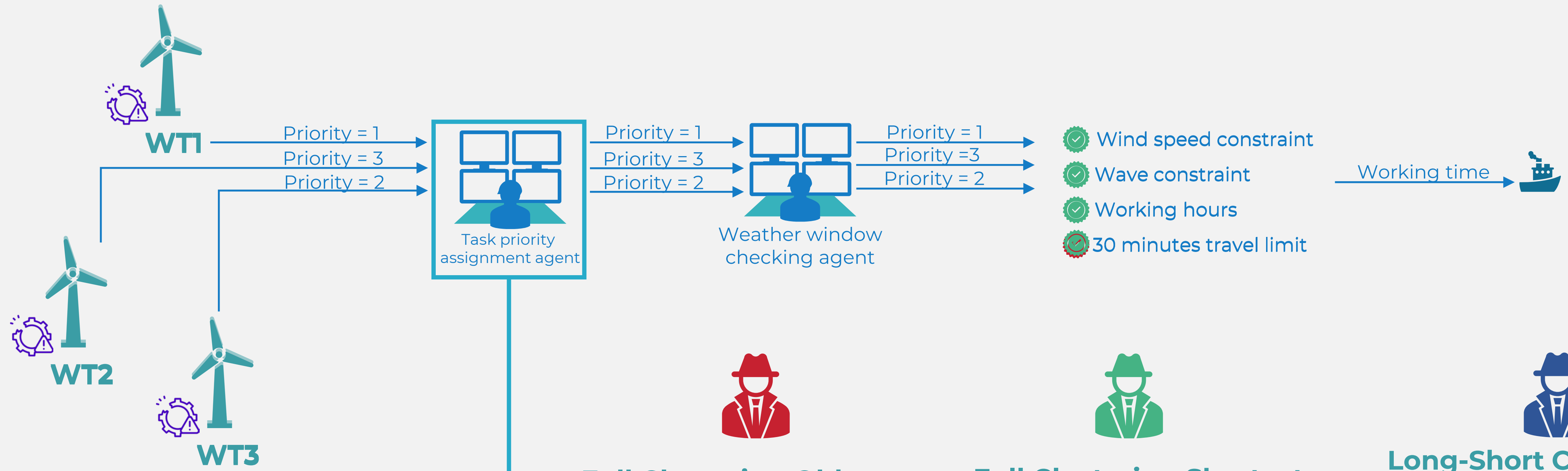
10 technicians working on a 4 week shift schedule followed by 4 weeks off.

Dedicated teams are assigned

Fixed costs per month per person: 16500 Euros

THE CONTROL ROOM

CASE STUDY



Full Clustering Oldest Task First (FC-OTF)

- In order of first come first served (FCFS), plan as many tasks as possible, and later re-arrange them based on their location.

Full Clustering Shortest Repair Time First (FC-SRTF)

- Plan as many tasks as possible based on the shortest repair time, and re-arrange them based on their location

Long-Short Clustering Shortest Repair Time First (LSC-SRTF)

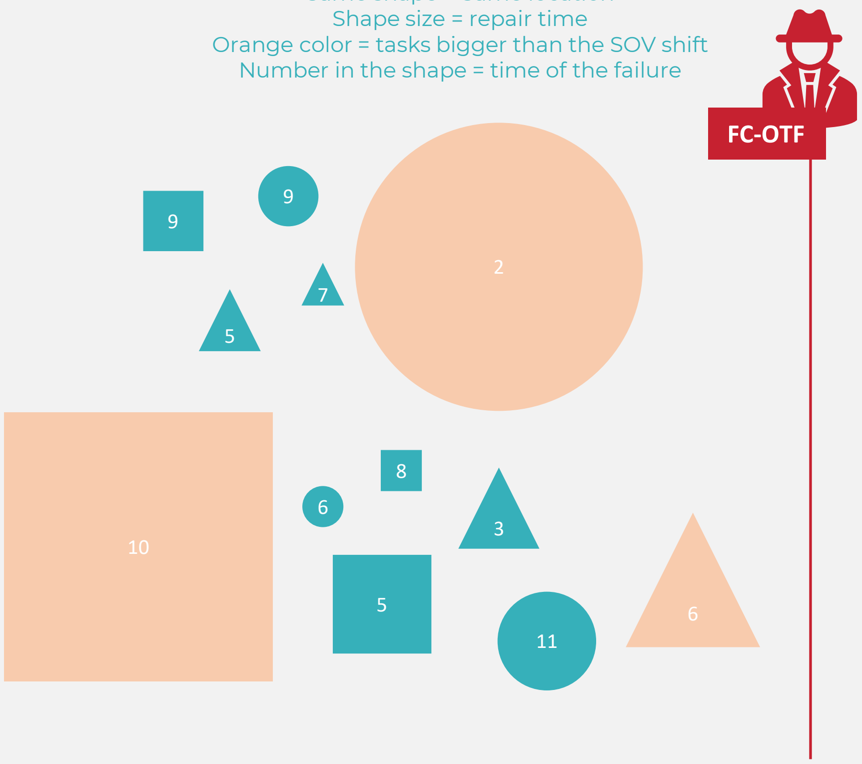
- Plan as many tasks as possible based on the shortest repair time and later re-arrange them based on their repair category.

THE CONTROL ROOM

CASE STUDY

Full Clustering Oldest Task First (FC-OTF)

Same shape = Same location
Shape size = repair time
Orange color = tasks bigger than the SOV shift
Number in the shape = time of the failure



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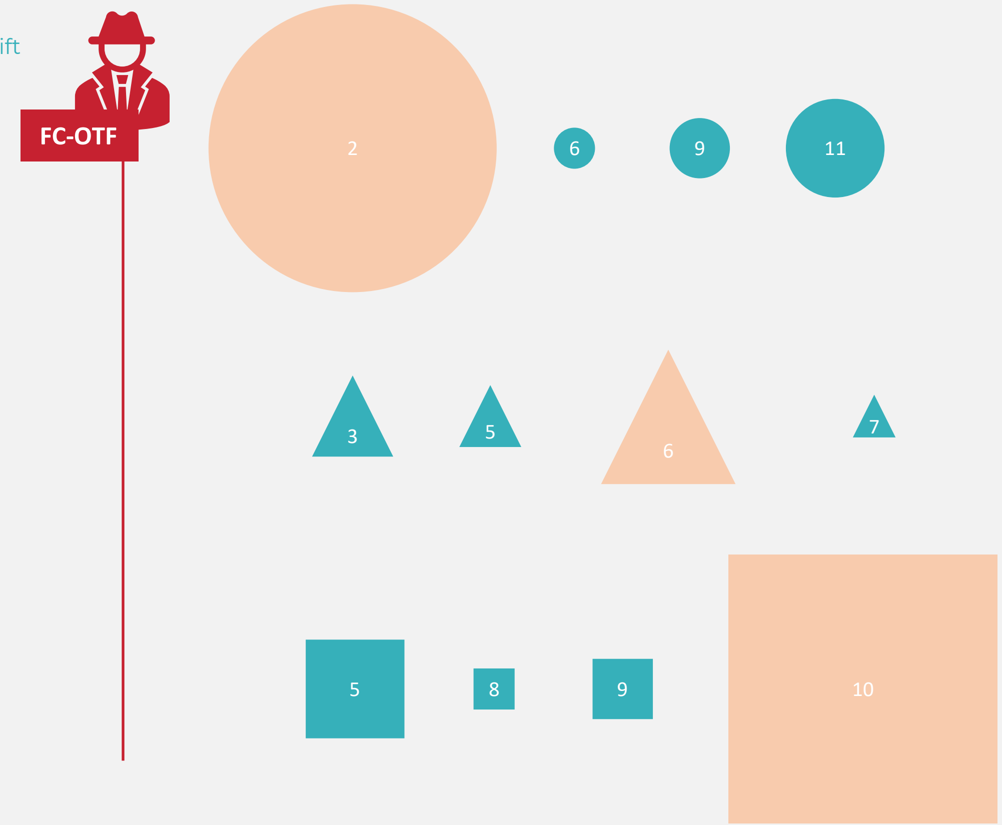

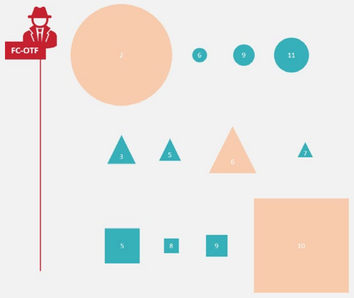

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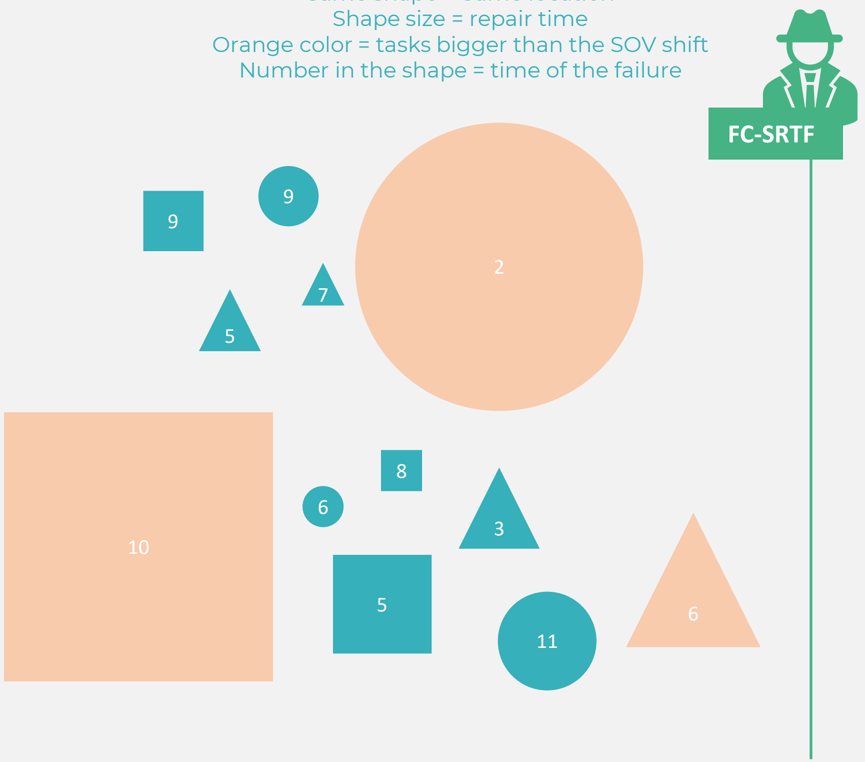

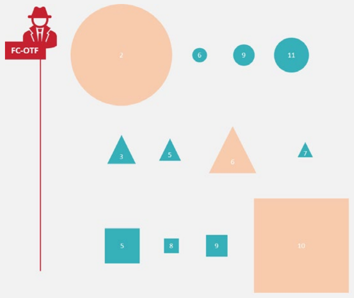

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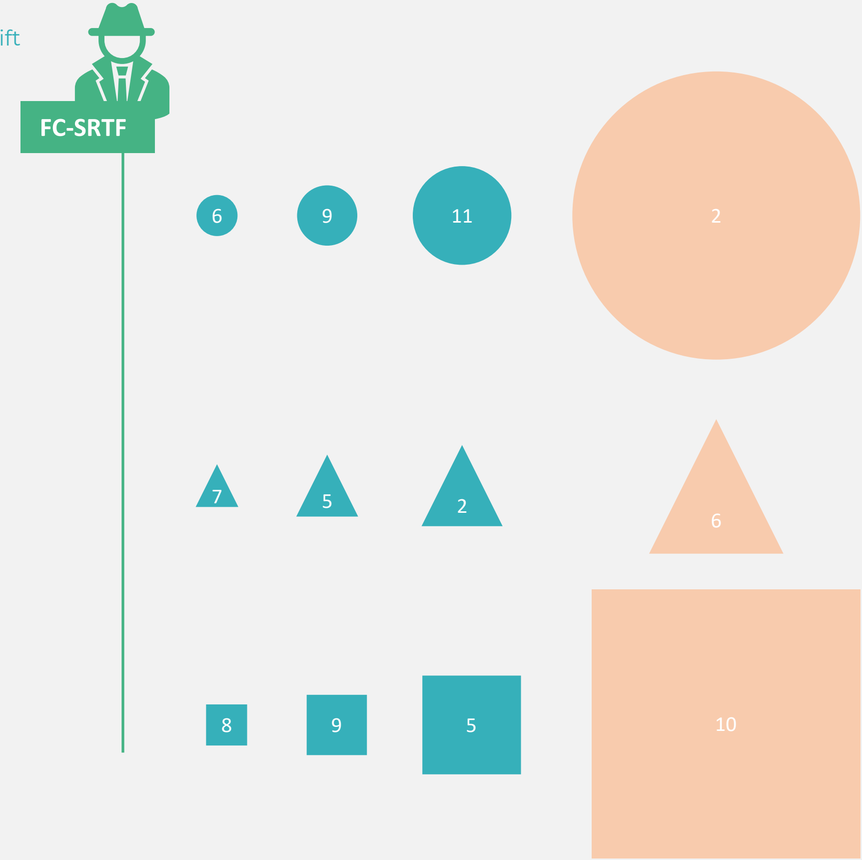

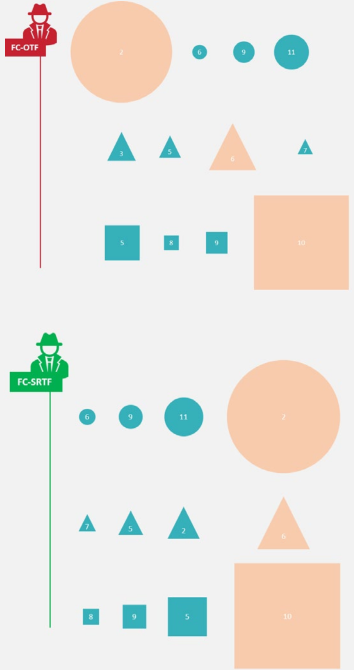

VENTARION HAW HAMBURG CC4E University of Strathclyde Glasgow RENEWABLE DYNAMICS

THE CONTROL ROOM

CASE STUDY

Long-Short Clustering
Shortest Repair Time First (LSC-SRTF)

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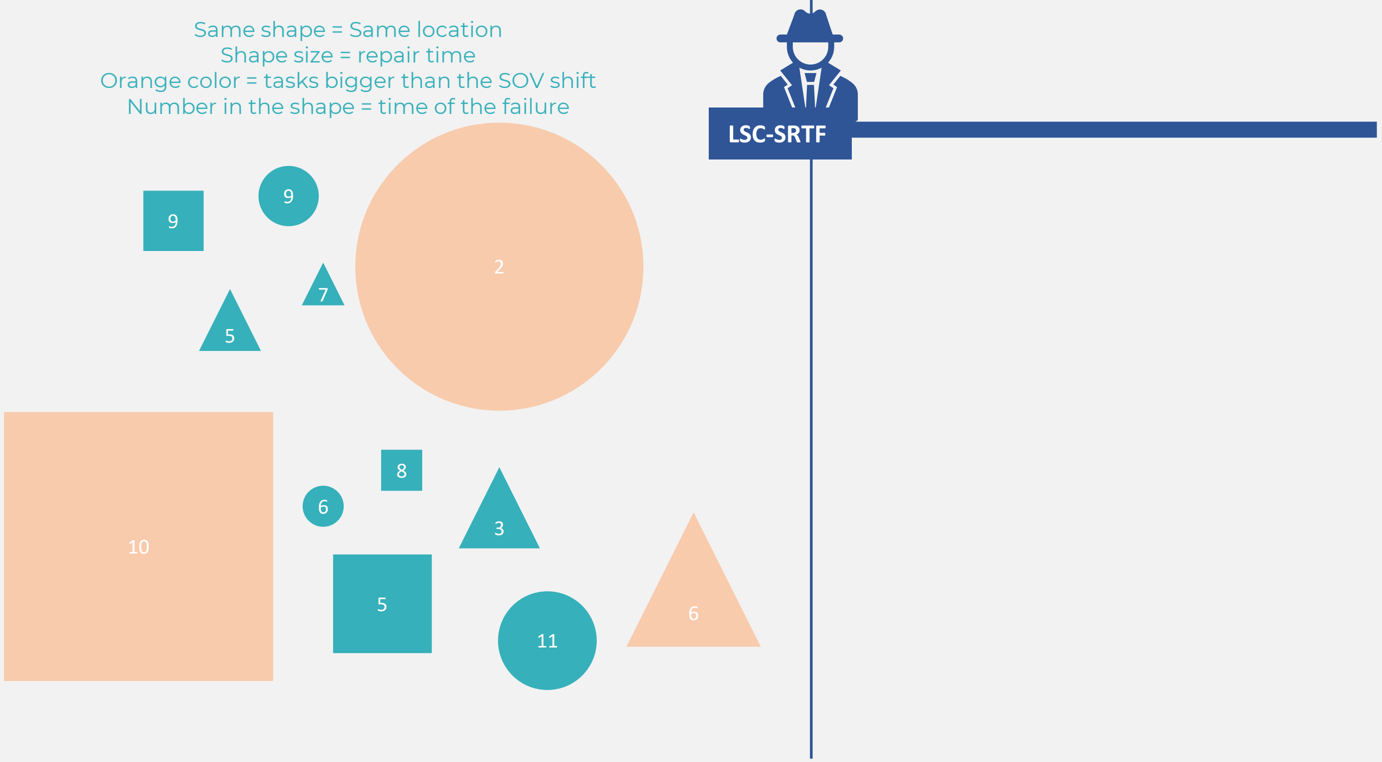

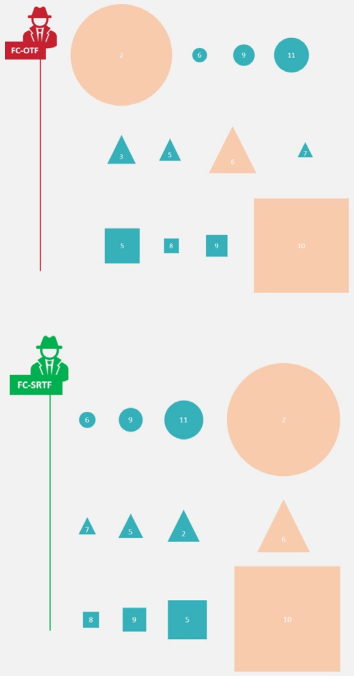

THE CONTROL ROOM

CASE STUDY

Long-Short Clustering Shortest Repair Time First (LSC-SRTF)

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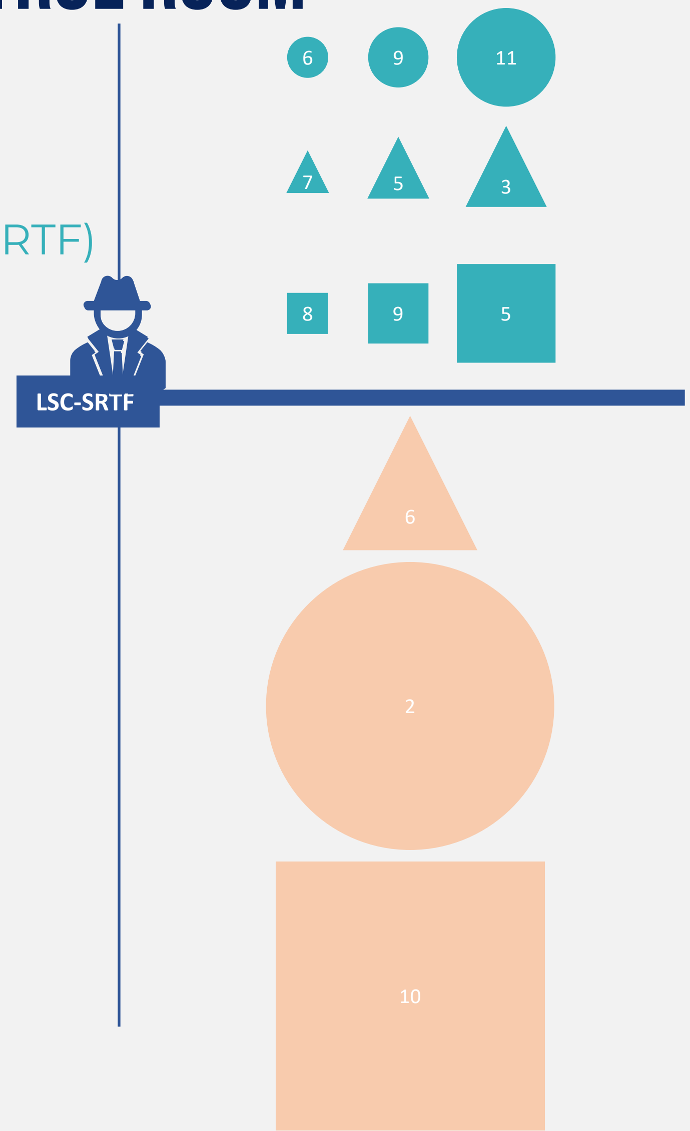
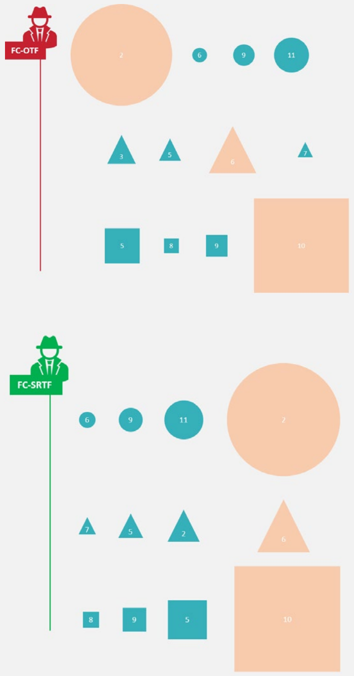


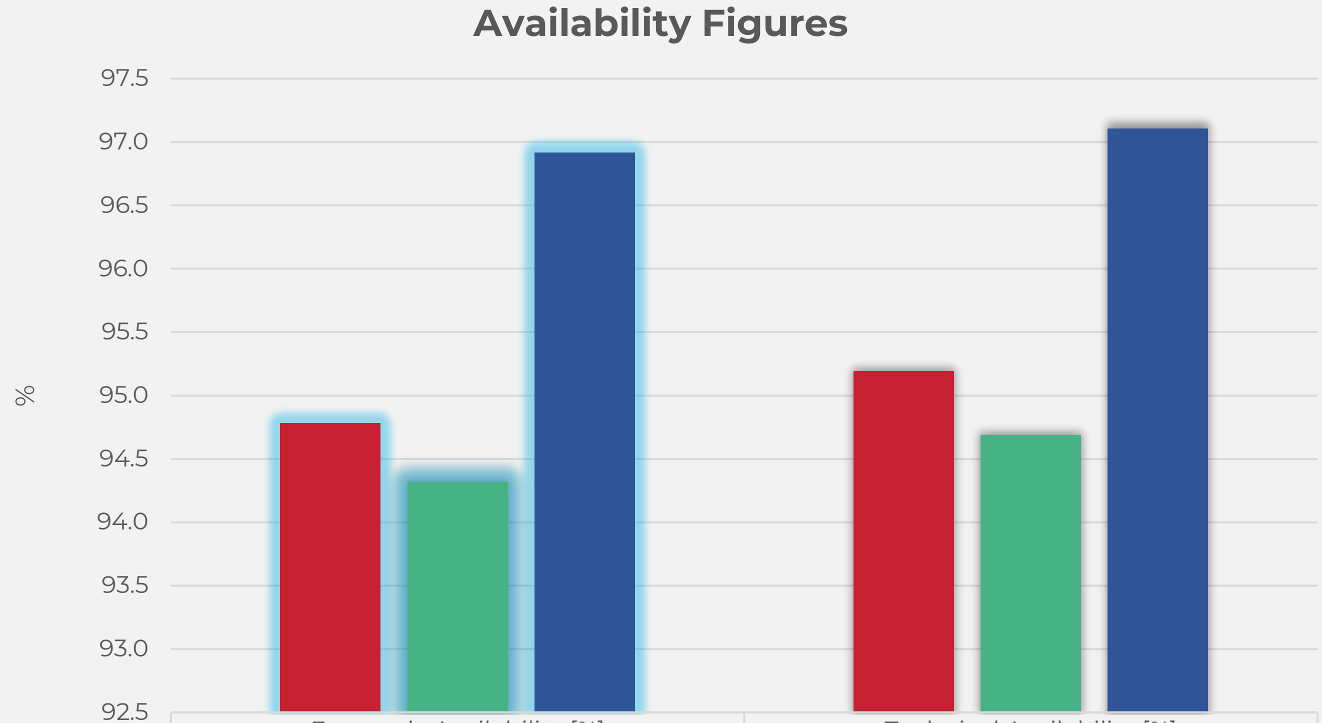


COMPARISON AVAILABILITY

Full Clustering Oldest Task First (FC-OTF)

Full Clustering Shortest Repair Time First (FC-SRTF)

Long-Short Clustering Shortest Repair Time First (LSC-SRTF)



	Energetic Availability [%]	Technical Availability [%]
FC-OTF	94.8	95.2
FC-SRTF	94.3	94.7
LSC-SRTF	96.9	97.1

COMPARISON POWER PRODUCTION

CASE STUDY

Full Clustering Oldest Task First (FC-OTF)

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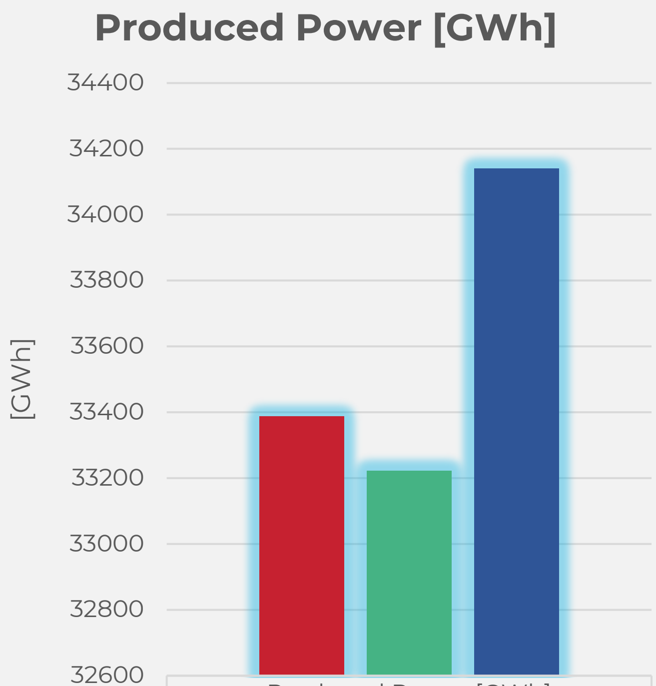
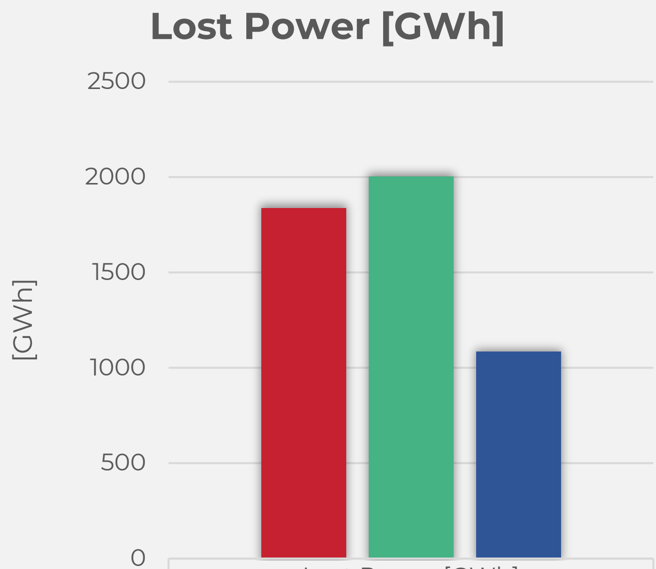
Long-Short Clustering Shortest Repair Time First (LSC-SRTF)



	Produced Power [GWh]
FC-OTF	33388
FC-SRTF	33224
LSC-SRTF	34140



	Lost Power [GWh]
FC-OTF	1838
FC-SRTF	2002
LSC-SRTF	1086

COST COMPARISON

Full Clustering Oldest Task First (FC-OTF)

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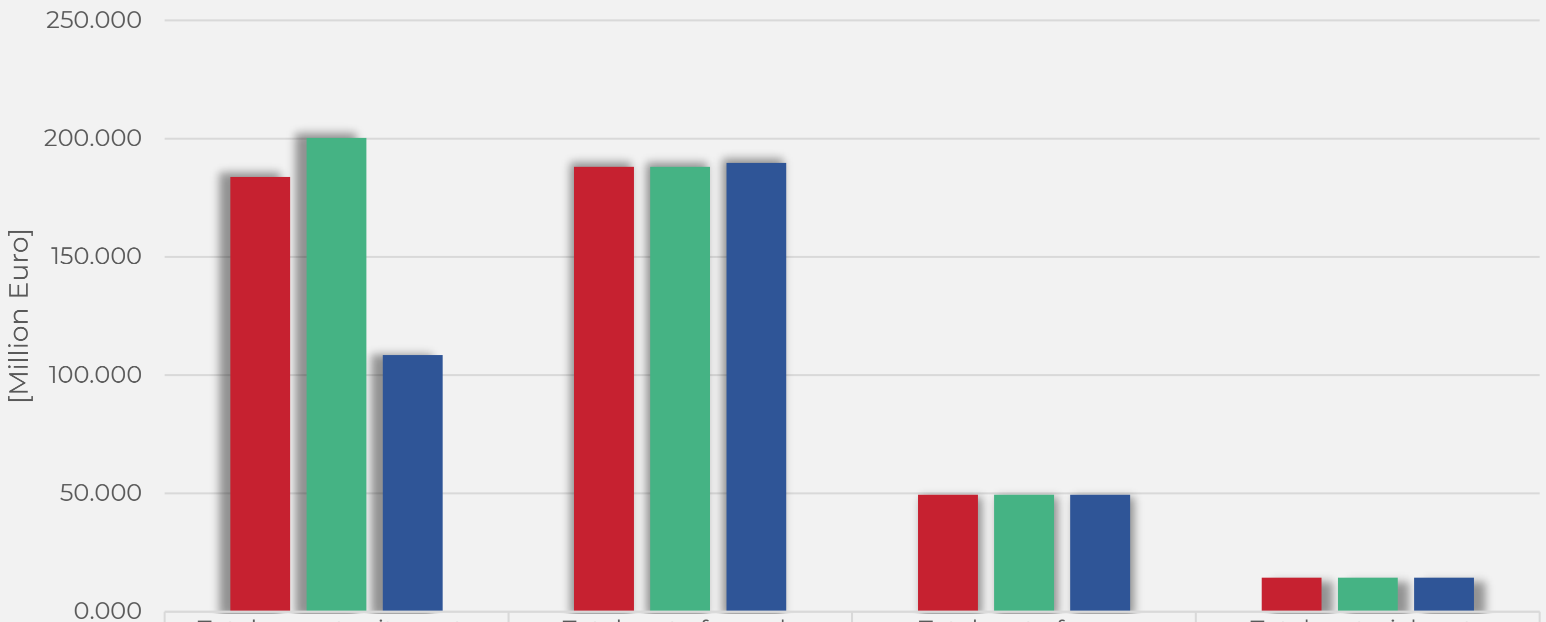
Long-Short Clustering Shortest Repair Time First (LSC-SRTF)

Cost Breakdown



	Total opportunity costs	Total cost of vessels	Total cost of crew	Total material costs
FC-OTF	183.781	188.112	49.500	14.381
FC-SRTF	200.221	188.106	49.500	14.381
LSC-SRTF	108.553	189.735	49.500	14.381

COMPARISON BACKLOG

Full Clustering Oldest Task First (FC-OTF)

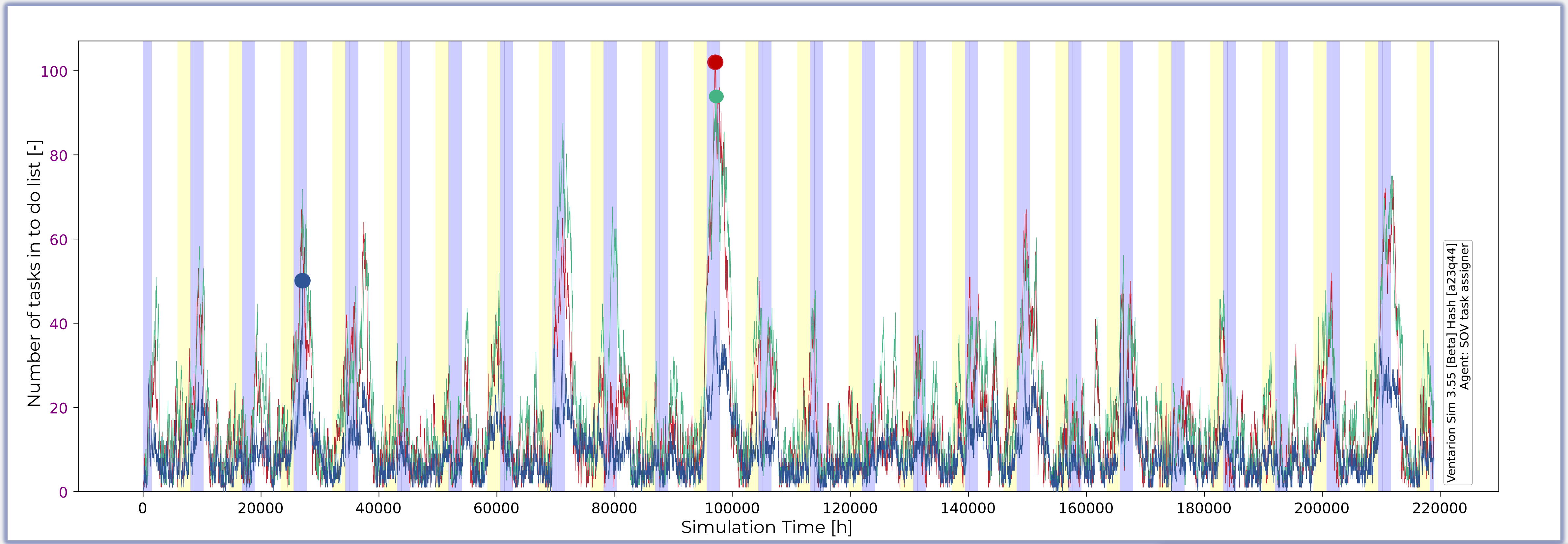
Maximum: 102
Average: 16.8

Full Clustering Shortest Repair Time First (FC-SRTF)

Maximum: 89
Average: 18.5

Long-Short Clustering Shortest Repair Time First (LSC-SRTF)

Maximum: 50
Average: 10.5



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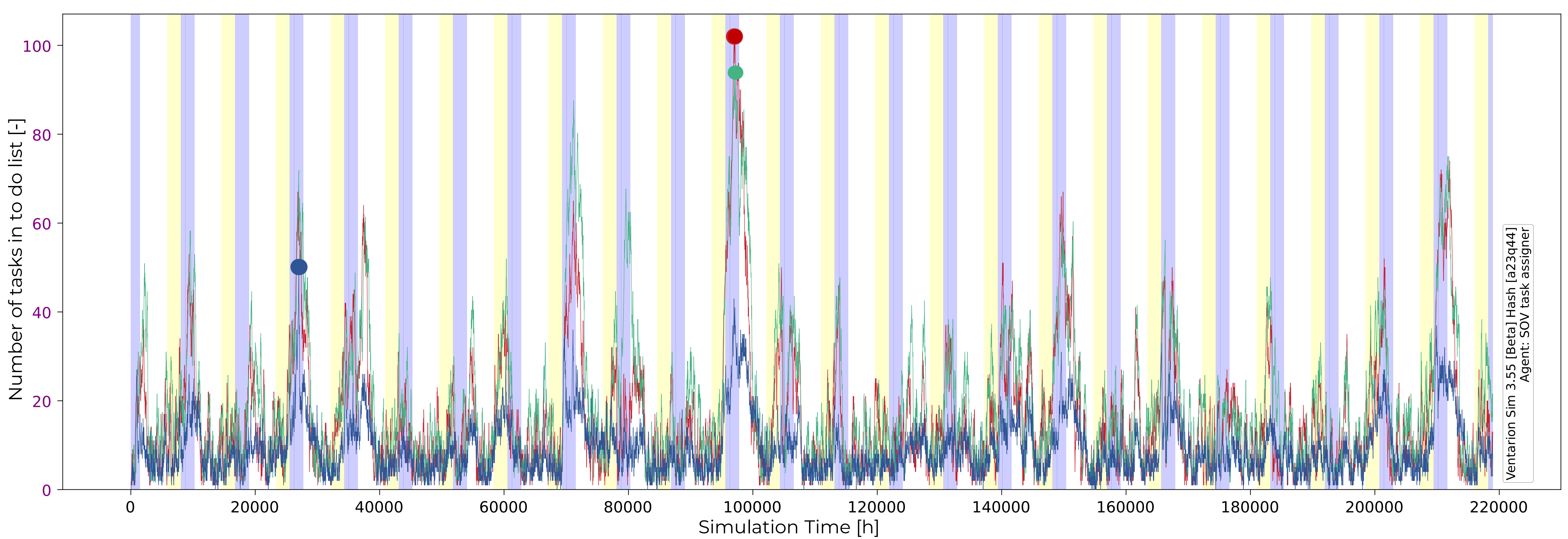

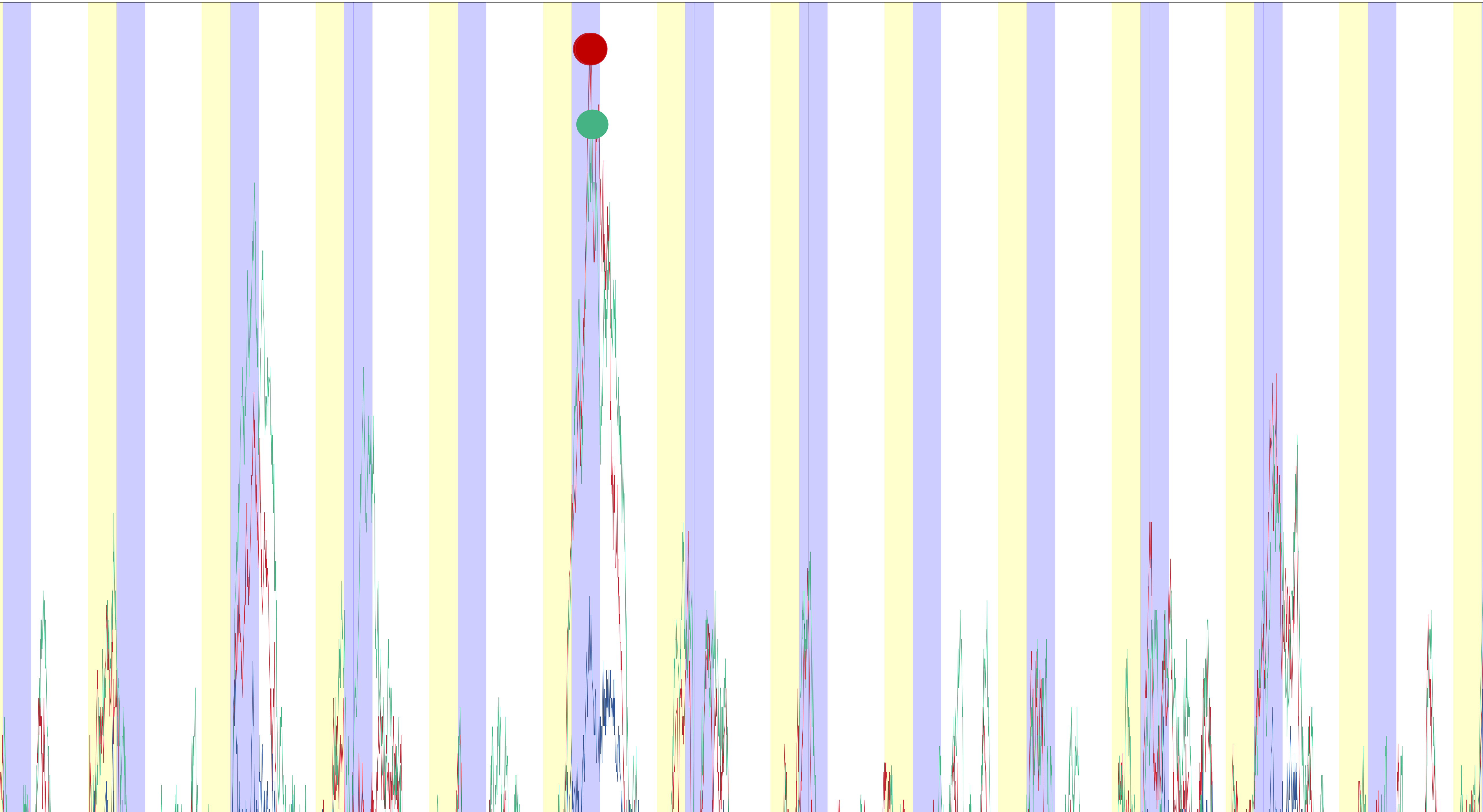

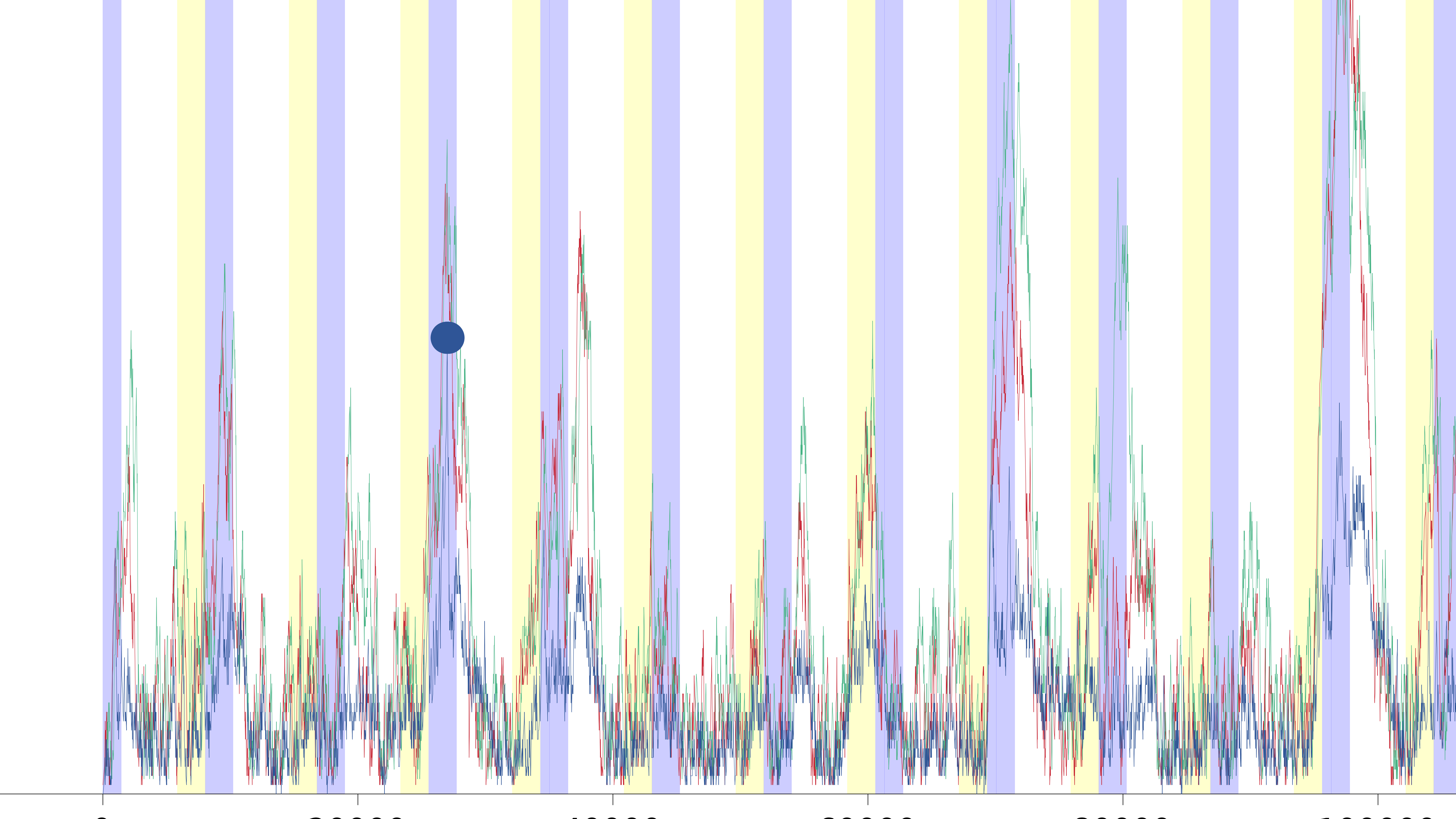

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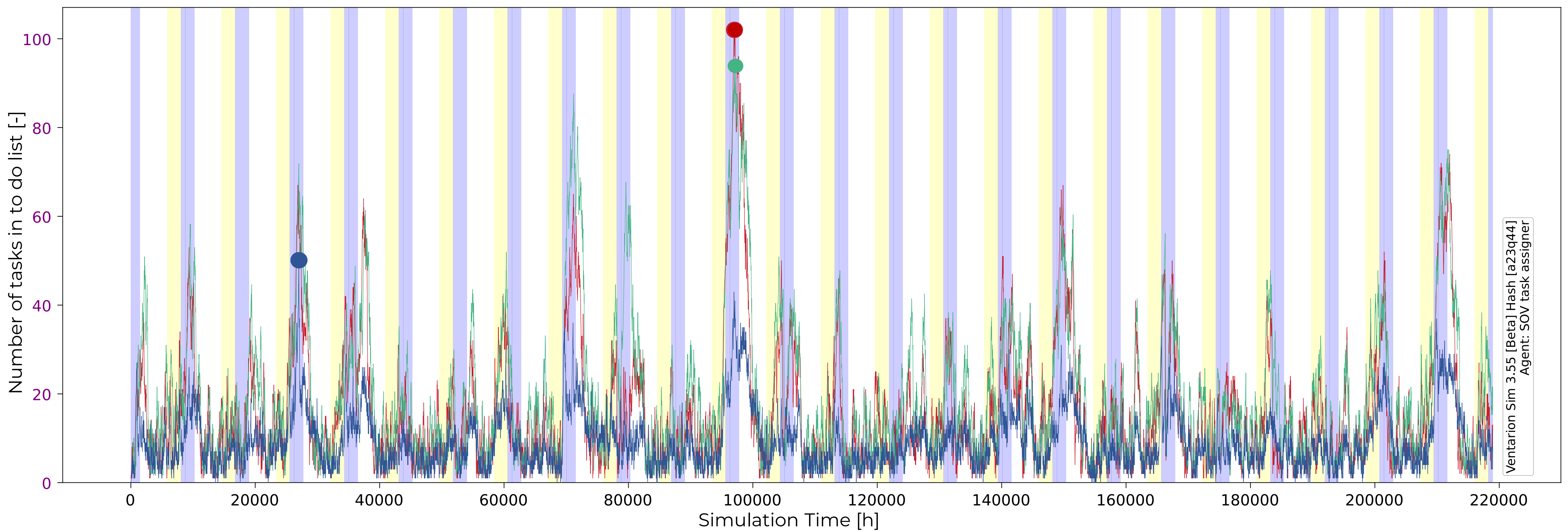

INSIGHTS

INSIGHTS

- By applying optimized response strategies, Multi Rotor System (MRS) availability can be improved by approximately 2% without adding new resources.
- Between the clustering based on location or repair time, a hybrid solution by clustering into long and short tasks and later based on shortest repair time first (LSC-SRTF) is the optimum solution.
- There is no universal solution; every wind farm has a unique failure profile that requires tailored response and maintenance strategies.
- A high number of small failures can be advantageous if managed proactively; however, poor management can lead to maintenance backlogs and reduced overall availability.
- Repair duration is as important as failure frequency, numerous short-duration repairs can often be completed in parallel to improve system uptime.
- Planned maintenance is essential and should not be neglected; performing major maintenance during spring and summer significantly lowers long-term costs and enhances winter reliability and availability.

Thank you for your attention!

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REFERENCES

[1] *Dr Anthony Gray. (2020, August). Https://cms.ore.catapult.org.uk/wp-content/uploads/2020/08/OM_Model_Review_Paper_FINAL-2.pdf. https://cms.ore.catapult.org.uk/wp-content/uploads/2020/08/OM_Model_Review_Paper_FINAL-2.pdf*

[2] Dinwoodie, I., Endrerud, O.-E. V., Hofmann, M., Martin, R., & Sperstad, I. B. (2015). Reference Cases for Verification of Operation and Maintenance Simulation Models for Offshore Wind Farms. *Wind Engineering*, *39*(1), 1–14. https://doi.org/10.1260/0309-524X.39.1.1