ENERGY 能源

Floating LiDAR 浮動式光達

How to increase confidence in a new measurement technique

如何增加對一個新的測量技術的信心

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25th August 2016

The Agenda 議程

- **DNV GL background;　DNV GL 之背景**
- **Floating LiDAR technology;　浮動式光達技術**
  - Introduction of LiDAR and floating LiDAR;　光達和浮動式光達之簡介
  - Opportunities & Challenges;　機遇與挑戰
  - Validation of floating LiDAR;　浮動式光達的驗證
- **How does floating LiDAR fare with other wind measurement data sources?**

  浮動式光達與其它測風數據源相比表現如何？
- **Why do improvement of uncertainty and P90/P50 values matter?**

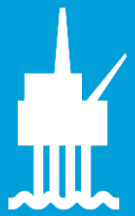
  降低不確定性和提高 P90/ P50 值重要嗎？
- **Floating Lidar in Taiwan?;　浮動式光達在台灣？**
- **What's next?;　下一步是什麼？**

DNV GL provides an unparalleled understanding of offshore risks: there is no substitute for hands-on experience
DNV GL 能提供對離岸風險之優等的理解：實踐經驗是不可替代的

DNV GL in offshore wind
DNV GL 在離岸風電

85 YRS
Electrical engineering

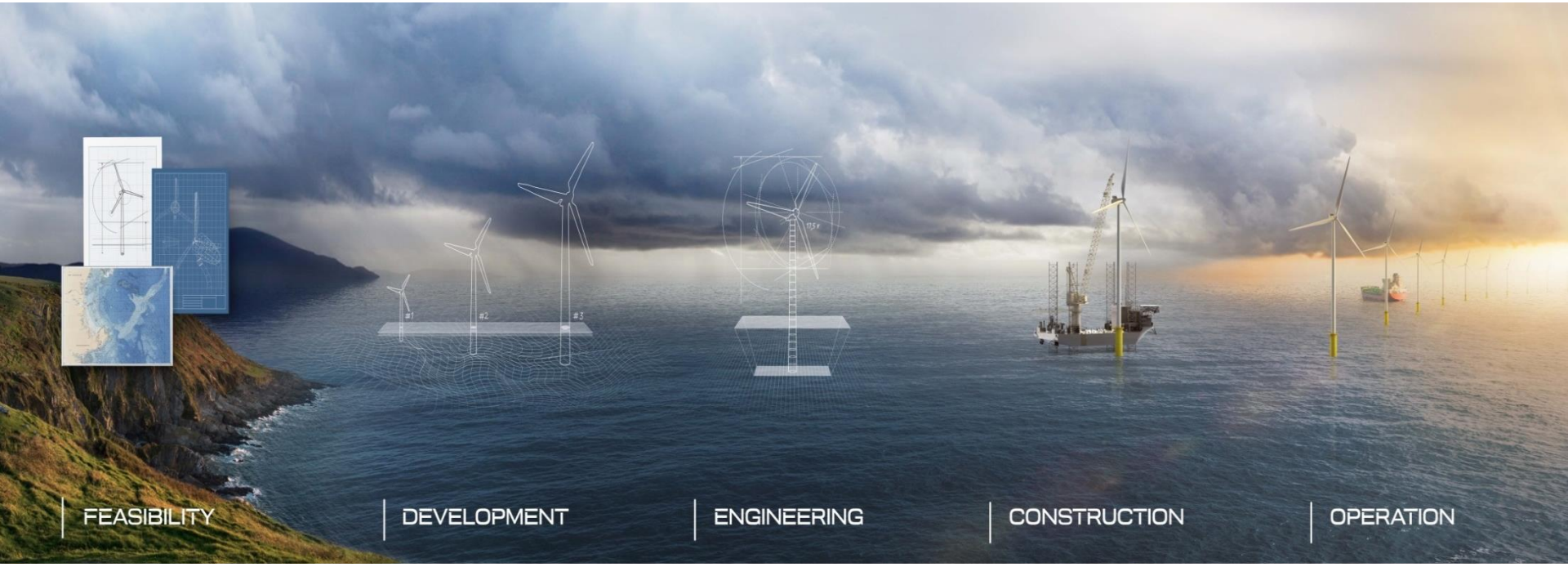
45 YRS
Offshore Oil and Gas



150 YRS
Shipping

30 YRS
Onshore Wind

That's why we always take a full lifecycle approach to provide the best informed business decisions
這就是為什麼我們始終以完整的生命週期之方法提供最佳的業務決策



- Market intelligence
- Strategic advice
- Technology evaluation

- Concept selection
- Measurement
- Resource and energy optimization
- Company due diligence
- Pre-construction energy assessment

- Project engineering optimization
- Operation and maintenance planning
- Turbine and support structures consulting
- Interconnection review

- Construction optimization
- Monitoring and marine warranty
- Project management
- Banks' Engineer
- Construction monitoring

- Asset optimization
- Operation and maintenance optimization
- Performance and condition monitoring
- Inspections & audits
- Operational Energy Assessments
- Project/portfolio due diligence

DNV·GL

Introducing LiDAR (Light Detection and Ranging)
光達介紹

- Remote sensing technology – commonly uses laser light (also near infrared and ultraviolet) to detect backscattered from aerosols

  遙感技術 – 通常使用激光（也近紅外線和紫外線）檢測來自氣溶膠後向散射

- Able to measure the aerosols as small as the wavelength used

  能夠測量小如使用波長的氣溶膠

- Similar working principle to SONAR – light instead of sound

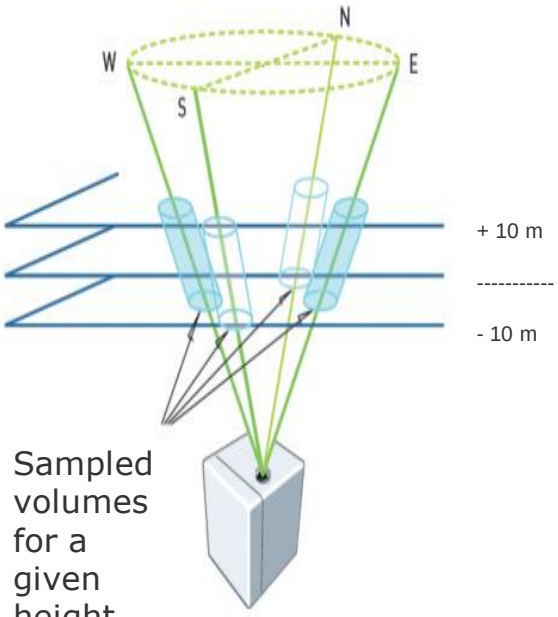
  類似聲納的工作原理 – 使用光而不是聲波

- Doppler-shift allows LiDAR to detect wind speed and directions

  多普勒頻移 (Doppler-shift) 讓光達可以探測風速和方向

- Generally profiler LiDAR is used in wind measurement campaigns with measuring interval ~10m

  一般說來，用於風力測量活動的光達之測量間隔~10米



Sampled volumes for a given height.
一定高度的採樣量

Floating LiDAR is basically…
浮動式光達基本上是…

- Taking onshore LiDAR that is proven and used in onshore wind measurements and mount it on buoys

  已在陸上風測量中使用以及被證明的光達，並將其安裝在浮標上

- Made to be autonomous and robust to operate in remote areas for long periods of time to collect and transmit data to wind engineer/analysts

  為了能在偏遠地區操作很長一段時間來收集和傳輸數據給風工程師/分析師而設基得既自主又穩健

- Improvements in mooring system design increases survivability in deployments

  系泊系統設計的改進提高了操作中的生存性

The opportunities of floating LiDAR are…
浮動式光達的機遇…

- Provides onsite measurements at a much lower cost than onsite met mast

  以相比現場氣象桅杆低得多的成本提供現場測量

- Measure wind shear without the need to mount various sensors at intervals on a tall mast

  不需要在一個高大的桅杆每隔一段高度安裝各種傳感器就可以測風切變

- Relative ease to deploy to offshore sites

  相對容易部署到離岸風場

… and these challenges that are being addressed
…和這些正在被解決的挑戰

- Ensuring wind speed and direction accuracy
  確保風速和風向之測量的準確度
- Remote sites ; 偏遠的操作地點
- Poor system availability; 不佳的系統可用性
- Uncertainty; 不確定性
- No standard for validation nor wind resource assessments available
  現階段的驗證和風資源評估還沒有標準
- Lack of investors' confidence; 投資者缺乏信心

However, the technology is new and validation is needed. Here are some criteria and findings to look out for.
然而，該技術是新的，還需驗證。這裡有一些標準和結果可做參考。

- Published validation results

  公佈的驗證結果

- Carbon Trust Offshore Wind Accelerator roadmap (Henceforth 'OWA roadmap')

  碳信託離岸風電加速開發計畫路線圖（下稱“OWA 路線圖”）

- IEA Wind Annex 32 to publish Recommended Practice for floating LiDAR

  IEA Wind 附件 32 將公佈的浮動式光達推薦做法

The better floating LiDARs in the market are at Stage 2
在市場上較好的浮動式光達正處於第二階段

Baseline 底線 Stage 1 第一階段	Pre-commercial 預商業 Stage 2 第二階段	Commercial 商業 Stage 3 第三階段
▪ LiDAR used in the floating LiDAR should be **'proven technology'** in onshore wind industry 在浮動式光達中使用的光達需是在陸上風電行業的 **"成熟技術"**	▪ **Validation onshore** against high-quality conventional anemometry 在**陸上**與優質常規風速計進行**驗證** ▪ **Validation offshore** against offshore met masts 在**海上**與離岸氣象桅杆進行**驗證**	▪ **Good operational experience and accuracy** achieved across a number of pre-commercial deployments. **良好的運作經驗和準確性**跨越多個預商業部署的實踐。 ▪ **Accumulation of enough evidence** to relax the elevated uncertainty assumptions **積累足夠的證據**以放鬆不確定性值的過高假設

A few key points from OWA roadmap on the 3 stages

OWA路線圖的3個階段中的幾個關鍵點

… and these KPIs
…和這些關鍵績效指標

OWA roadmap KPIs

OWA 路線圖關鍵績效指標

	OWA roadmap KPIs
Overall Post-processed Data Availability	>85 %
Mean Wind Speed - Slope	0.98 – 1.02 (Best Practice)
Mean Wind Speed – Coefficient of Determination (R2)	>0.98 (Best Practice)
Mean Wind Direction – Coefficient of Determination (R2)	>0.97 (Best Practice)

Advantages and disadvantages of the 4 different offshore wind measurement data sources
4種不同離岸測風數據源的優勢與缺點

Data source	Advantages	Disadvantages
Public wind maps & virtual model data	✓ Low cost and easy ✓ Wide spatial coverage	× Limited accuracy × Low resolution
Public measurements	✓ Low cost and easy ✓ Wide spatial coverage	× Inaccuracies when extrapolating to heights × Reliance on models
Fixed LiDAR on near offshore platform	✓ Measure wind shear at more points	× Costly offshore platform × Flow distortion
Floating LiDAR	✓ Easy to deploy ✓ Measure wind shear at more points	× Sensitive to metocean phenomena
Onsite offshore met mast	✓ Best accuracy	× High cost × Flow distortion

DNV GL examines uncertainty analysis from these data sources
DNV GL 檢討這些數據源的不確定度分析

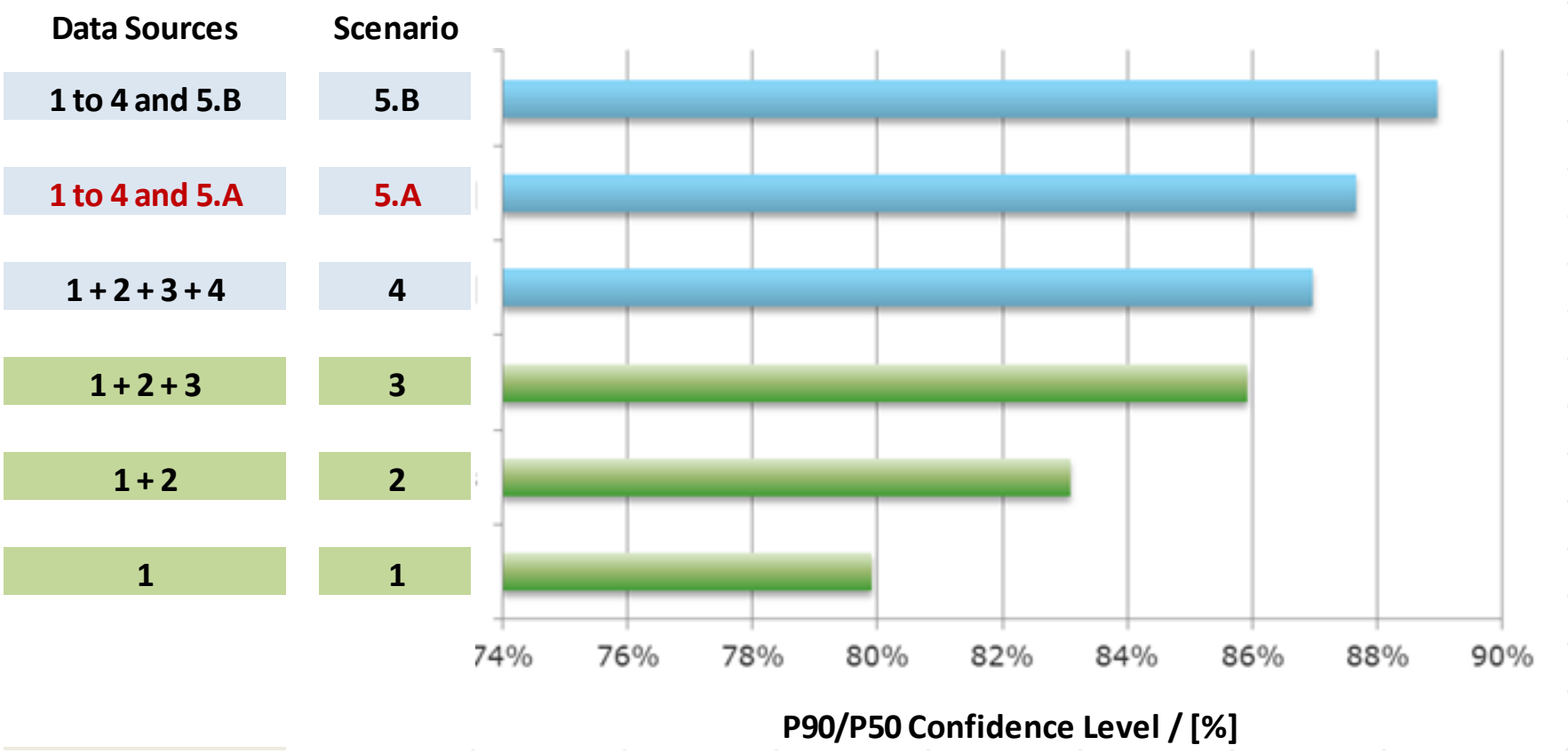
Data sources	Description
1	Public wind maps & virtual weather model data
2	Public measurements
3	Public wind data from offshore mast and weather stations (remote)
4	Fixed LiDAR on near offshore platform
5.A	**Stage-2 Floating LiDAR @ centre of site**
5.B	Tall Offshore Met Mast @ centre of site

...which gives us these uncertainty values in wind assessment
...這讓我們從風能評估得到這些不確定性值

Data Sources	1	2	3	4	5.A	5.B
Typical Wind Speed Uncertainties	[%]	[%]	[%]	[%]	[%]	[%]
Anemometer Accuracy	10.0	4.0	2.0	-	-	2.0
LiDAR Accuracy	-	-	-	2.5	4.0	-
Flow Distortion	-	4.0	2.0	1.0	-	1.0
Period Representing Long-Term	1.9	1.9	1.9	1.9	1.9	1.9
Wind Flow Modelling – Vertical	-	4.0	-	-	-	-
Wind Flow Modelling – Horizontal	1.0	4.0	5.0	4.0	1.0	1.0
Correlation to Reference	-	-	2.0	2.5	2.5	2.5
Correlation to Reference (Weighted)	-	-	1.2	2.3	2.3	2.3
Consistency of Reference Source	-	-	0.9	0.9	0.9	0.9

Note: More than 12 months of wind measurement

...resulting in these effects on P90/P50 Confidence Level
...從而對 P90/ P50 置信水平的影響



Note: More than 12 months of wind measurement

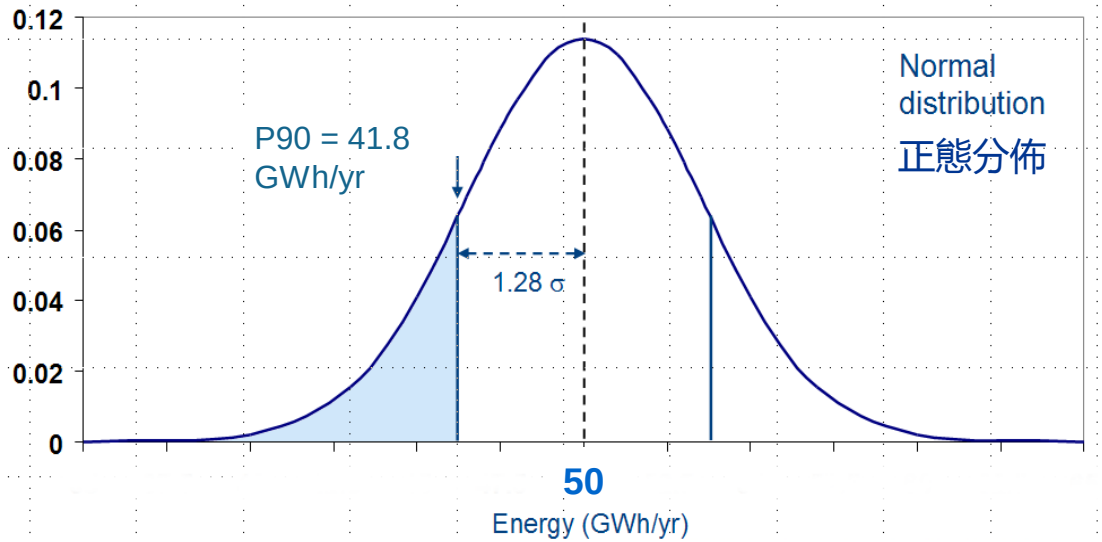
Higher confidence level and less uncertainty gives banks more confidence to loan
更高的置信水平和更少的不確定性使銀行更放心貸款

- Wind project financial transactions need robust uncertainty analyses to allow appropriate modelling of risk

  風力發電項目的金融交易需要穩健的不確定性分析，以允許對風險適當的建模

- Better data & analysis = less uncertainty = more reliable predictions = less risk

  更好的數據和分析 = 更少的不確定性 = 更可靠的預測結果 = 風險更小



As more offshore sites in Taiwan are planned for wind farms, floating LiDAR should be considered in Taiwan because…
隨著台灣有更多的離岸風場計劃，浮動式光達應在台灣被受考慮因為…

- **Cost-effective** – provides on-site data for much lower costs since offshore platform is unnecessary

  成本效益 – 以低成本提供現場數據，因為不需建造海上平台

- **High P90/P50 confidence level** – when used with other sources of data, a thoroughly planned on-site floating LiDAR

  高 P90/ P50 的信心水平 – 與其他數據源一起使用時，一個詳細計劃的現場浮動式光達

  – Which gives banks more confidence to loan (as discussed earlier)

    這給銀行更多的信心去貸款（如前所述）

**If floating LiDAR measurement campaign is performed correctly for at least 12 months*

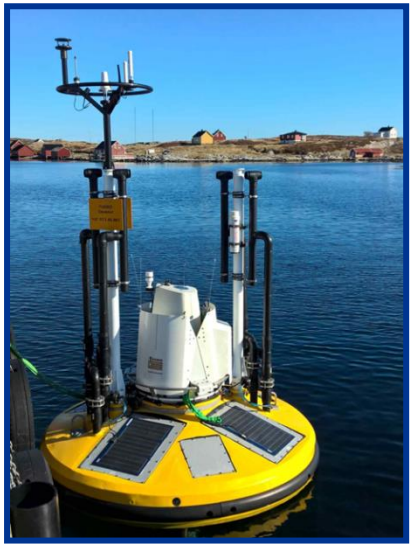
**若採用浮動式光達測量活動為至少 12 個月進行正確*

Image source: ECOFYS

DNV GL understands floating LiDAR
DNV GL 理解浮動式光達

- DNV GL has independently validated floating LiDARs
  DNV GL 有為浮動式光達進行過獨立驗證

Firm	Floating LiDAR	Validation Location
AXYS	FLiDAR	FINO1, NAREC and West of Duddon Sands
Fugro OCEANOR	SEAWATCH Wind LiDAR Buoy	Ijmuiden Met Mast, Holland
Babcock	FORECAST Floating ZephIR LiDAR	Gwynt y Môr, UK



What's next?
下一步是什麼？

Baseline 底線
Stage 1 第一階段

- LiDAR used in the floating LiDAR should be **'proven technology'** in onshore wind industry

  在浮動式光達中使用的光達需是在陸上風電行業的 **"成熟技術"**

Pre-commercial 預商業
Stage 2 第二階段

- **Validation onshore** against high-quality conventional anemometry

  在**陸上**與優質常規風速計進行**驗證**

- **Validation offshore** against offshore met masts

  在**海上**與離岸氣象桅杆進行**驗證**

Commercial 商業
Stage 3 第三階段

- **Good operational experience and accuracy** achieved across a number of pre-commercial deployments.

  良好的運作經驗和準確性跨越多個預商業部署的實踐。

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In conclusion
總而言之

- **Challenges are being addressed**, and more data is becoming available leads to **growing confidence** in the use of floating LiDAR
  挑戰正在被解決，隨著更多的可用數據出爐，成為對使用浮動式光達之**信心的不斷增長**

- In the **near future**, we will likely see **fully commercialised** floating LiDAR
  在**不久的將來**，我們將有可能看到**完全商業化**的浮動式光達

- DNV GL has the **experience** to support our clients to develop appropriate wind measurement campaigns to **maximise project value**
  DNV GL 擁有豐富的經驗來支持我們的客戶制定相應的測風活動，以**最大限度地提高項目價值**

Thank You

Look for us at the UK Pavilion, stand 320

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