

Charting the Future:

A Collaborative Advancement in Marine Weather Warning Communication with S-412

January 26, 2026

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...STORM WARNING...
.COMPLEX LOW WITH FIRST CENTER 55N167W 965 MB MOVING SW 10 KT THEN TURNING SE AFTER 12 HOURS AND SECOND CENTER 49N170W 968 MB MOVING NE 10 KT. BETWEEN 180 NM AND 480 NM NW SEMICIRCLE OF FIRST CENTER...AND BETWEEN 300 NM AND 540 NM SW SEMICIRCLE OF SECOND CENTER WINDS 40 TO 55 KT. SEAS 6 TO 10 M. ELSEWHERE WITHIN 180 NM SE SEMICIRCLE OF FIRST CENTER...N OF 30N BETWEEN 154W AND 168E...AND WITHIN 180 NM N AND E OF A LINE FROM 58N150W TO 55N144W TO 45N146W TO 34N155W WINDS 25 TO 40 KT. SEAS 3 TO 6.5 M.
.12 HOUR FORECAST COMBINED LOW NEAR 53N169W 974 MB. WITHIN 540 NM NW QUADRANT AND BETWEEN 420 NM AND 1200 NM SW QUADRANT WINDS 40 TO 55 KT. SEAS 6.5 TO 10.5 M...HIGHEST NEAR 55N174W AND 43N178W.
.24 HOUR FORECAST COMPLEX LOW WITH FIRST CENTER 52N166W 985 MB AND NEW SECOND CENTER NEAR 43N167W 998 MB. WITHIN 420 NM SE SEMICIRCLE OF FIRST CENTER...S OF THE ALEUTIAN ISLANDS BETWEEN 168W AND 176E...AND WITHIN THE BERING SEA 165W AND 177E WINDS 30 TO 45 KT. SEAS 4.5 TO 8.5 M...HIGHEST NW OF FIRST CENTER. ELSEWHERE N OF 30N BETWEEN 144W AND 170E...EXCEPT WHERE DESCRIBED WITH LOW 39N153W BELOW...WINDS 20 TO 30 KT. SEAS 3 TO 6 M IN MIXED SWELL...EXCEPT SEAS 2.5 TO 4 M WITHIN THE BERING SEA E OF 166W.
...GALE WARNING...
.24 HOUR FORECAST NEW LOW NW OF AREA NEAR 52N159E 1004 MB. N OF 45N W OF 170E WINDS 25 TO 40 KT. SEAS 3 TO 5 M IN SE SWELL.
.48 HOUR FORECAST LOW AND CONDITIONS ABSORBED BY LOW 54N160E ABOVE.



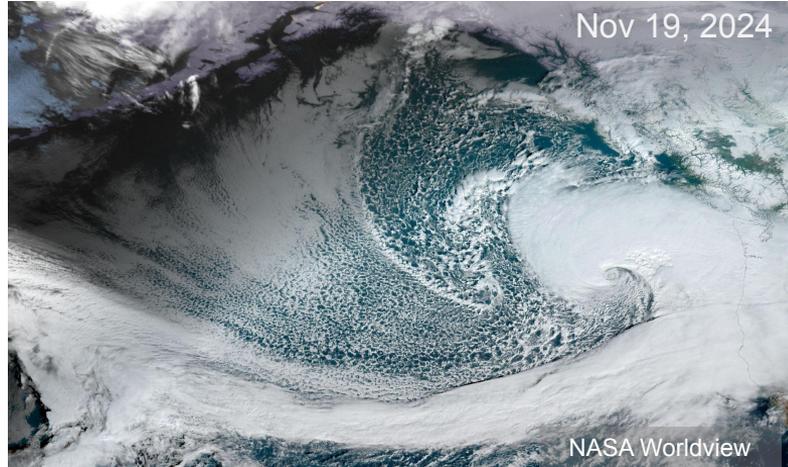


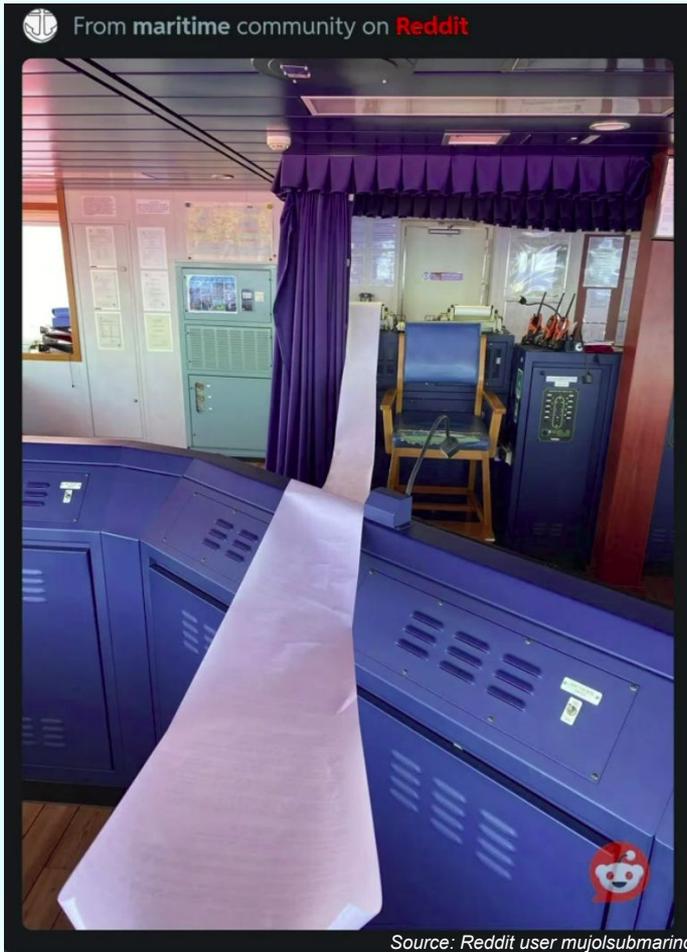
Importance of Safe and Efficient Navigation

- Marine transportation and operations are key components of the global supply chain
- Vessels operate through the global ocean in extremely harsh conditions



WORLD METEOROLOGICAL ORGANIZATION

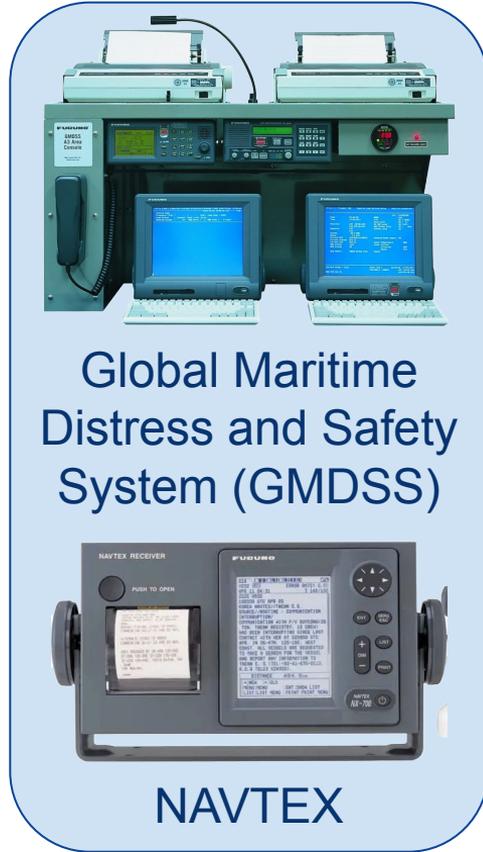




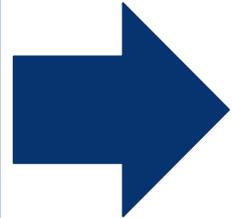
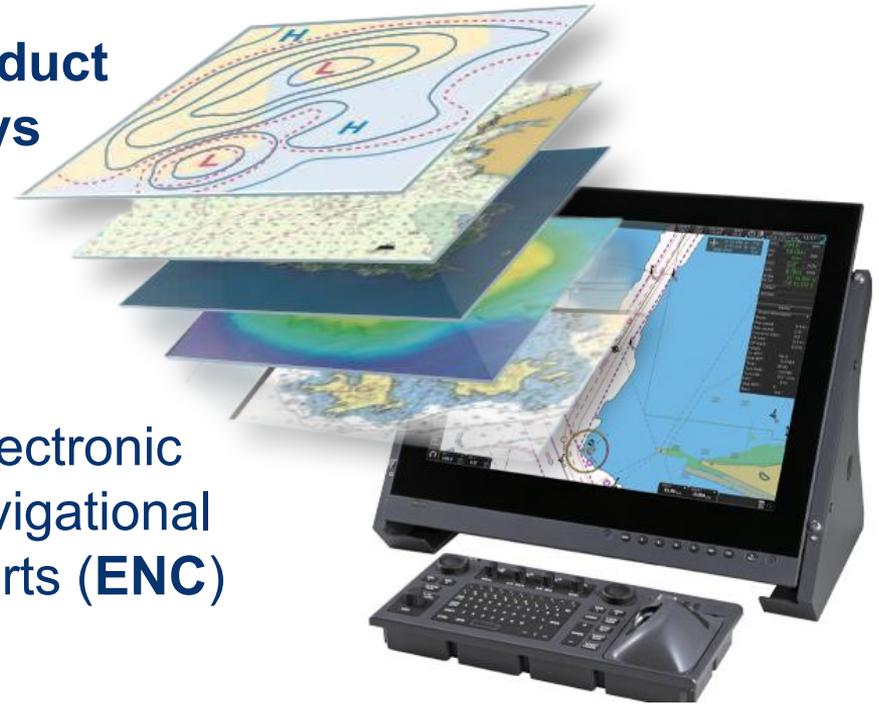
"A picture is worth
a thousand words
(of High Seas text)"



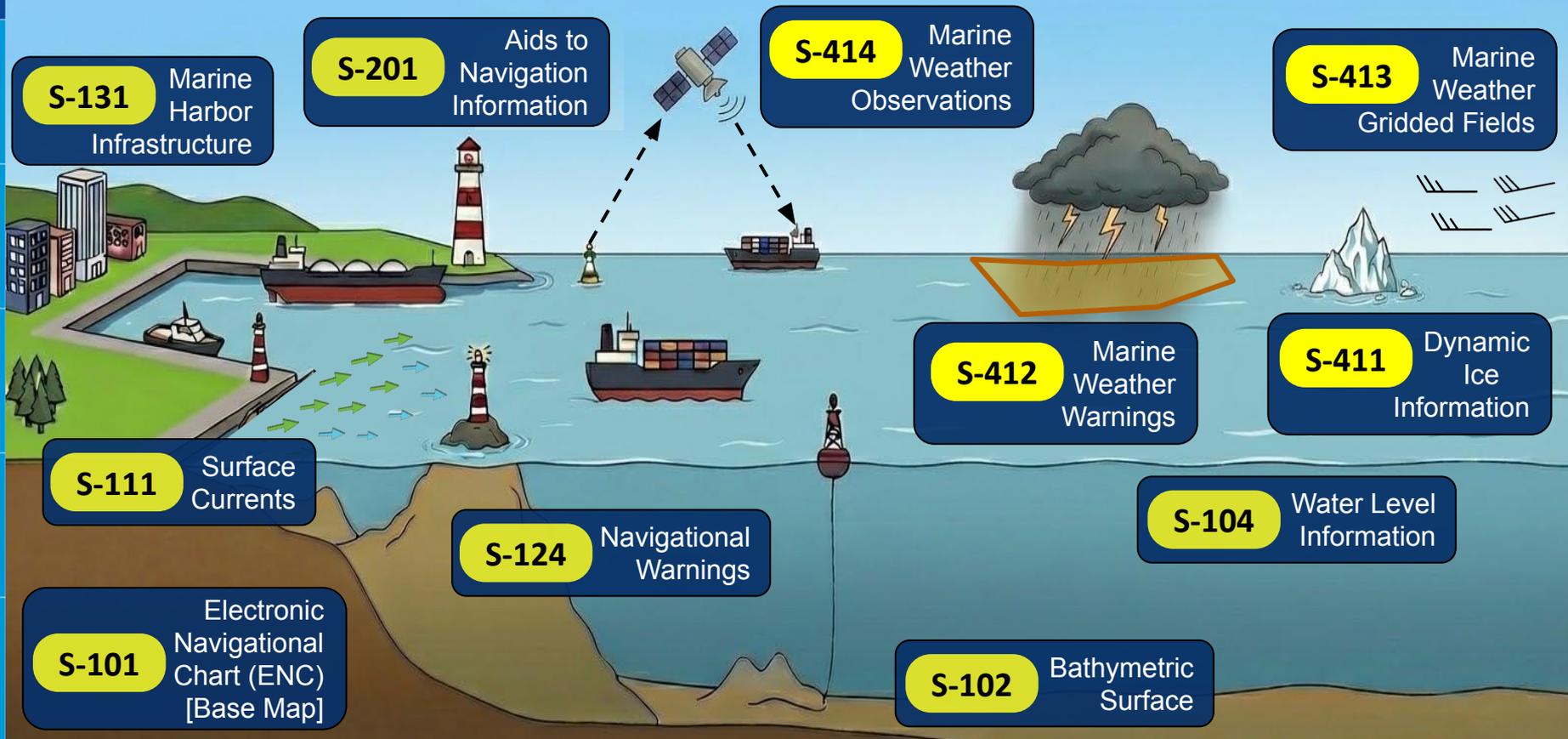
Modernization of Maritime Communication



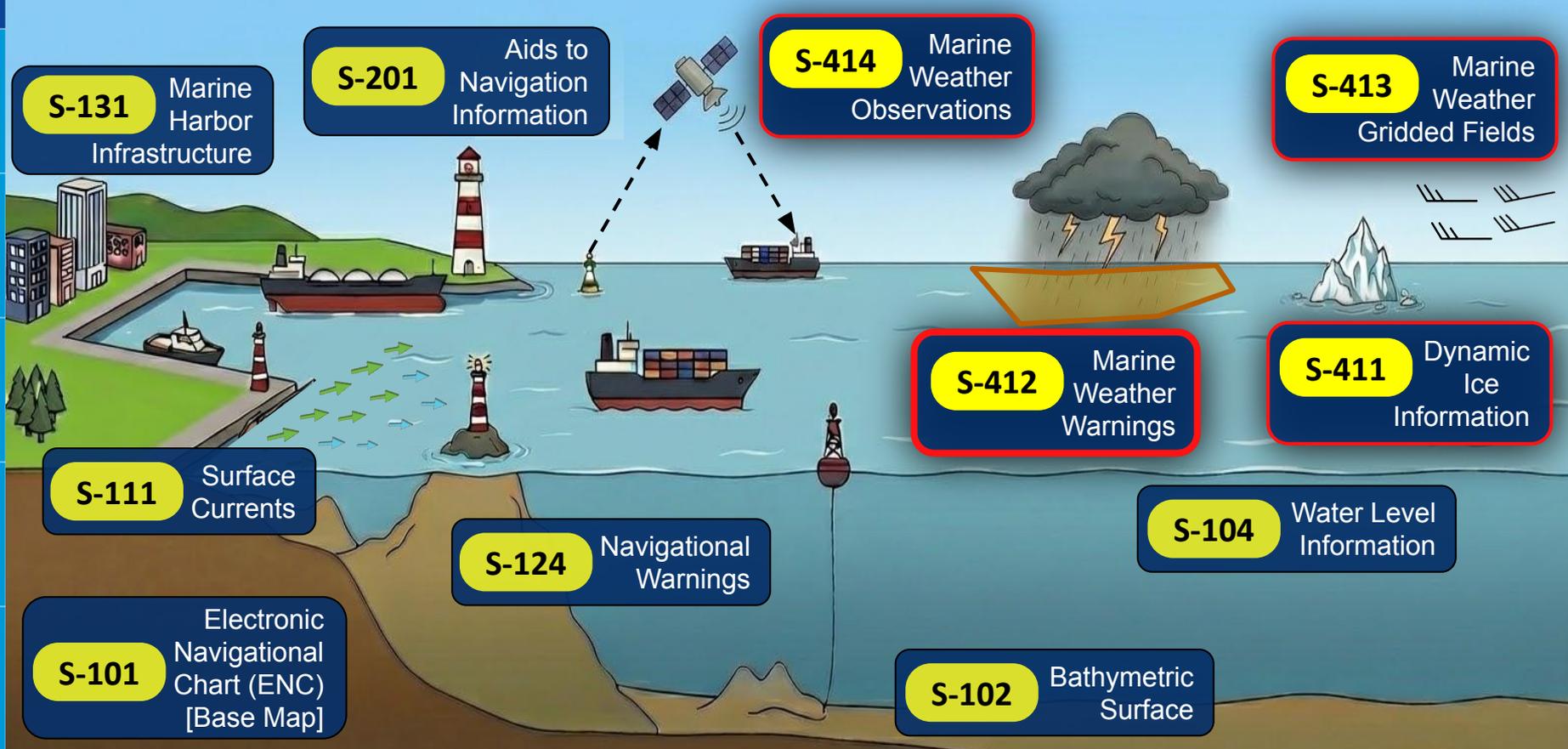
S-100 Product Overlays



S-100 Product Overlays



S-100 Product Overlays



S-412: Marine Weather Warnings

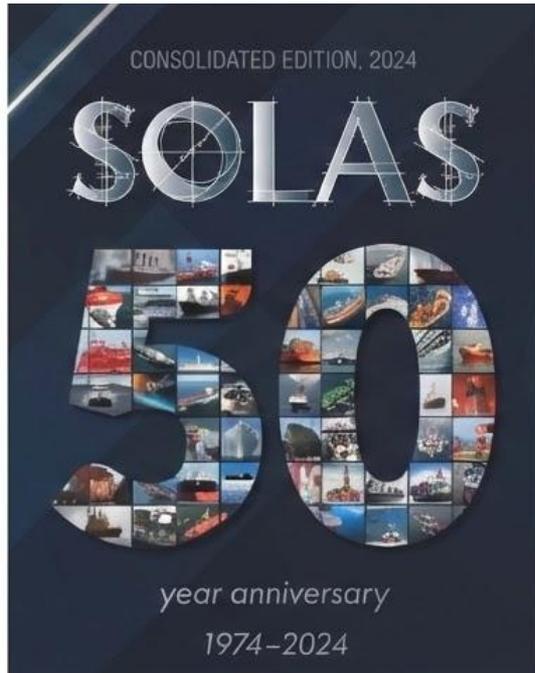
- The goal of S-412 is to encode information on meteorological and oceanographic warnings that are used by mariners for route-planning and hazard mitigation
- Warnings are produced for:
 - **Winds**
 - **Significant Wave Heights**
 - **Ice Accretion**
 - **Restricted Visibility**
 - **Thunderstorms**



Maritime Safety Requirements in S-412



- Safety of Life At Sea Convention (SOLAS) & Resolutions
- Maritime Safety Information (MSI)



WORLD
METEOROLOGICAL
ORGANIZATION

WMO-No. 558

Manual on Marine Meteorological Services

Volume I – Global Aspects

Annex VI to the WMO Technical Regulations

Polygon Portrayals for Warnings

.WARNINGS.

...STORM WARNING...

.LOW 46N148W 981 MB MOVING W 10 KT WITHIN 300 NM NE AND 240 NM NW QUAD 5 TO 8 M. ELSEWHERE FROM 39N TO 46N AND 170W TO 175W WINDS 25 TO 40 KT. SEAS 3.5 TO 6.5 M.

.24 HOUR FORECAST COMPLEX LOW WITH MEAN CENTER 42N150W WITHIN 240 NM NW QUADRANT WINDS 35 TO 45 KT. ELSEWHERE FROM 42N TO 60N BETWEEN 165W AND 175W WINDS 25 TO 40 KT. SEAS 4 TO 8 M.

.48 HOUR FORECAST COMPLEX LOW WITH MEAN CENTER 48N155W WITHIN 240 NM NW QUADRANT WINDS 45 TO 55 KT. ELSEWHERE FROM 44N TO 59N BETWEEN 165W AND 175W WINDS 25 TO 40 KT. SEAS 3 TO 6 M.

...STORM WARNING...

.LOW 47N168E 989 MB MOVING NW 25 KTS WITHIN 400 NM S AND SE QUADRANTS WINDS 40 TO 50 KT. SEAS 5 TO 9 M. 177W WINDS 25 TO 40 KT. SEAS 3 TO 5 M. .24 HOUR FORECAST LOW ABSORBED BY DESCRIBED WITH LOW 40N172E BELOW.

...STORM WARNING...

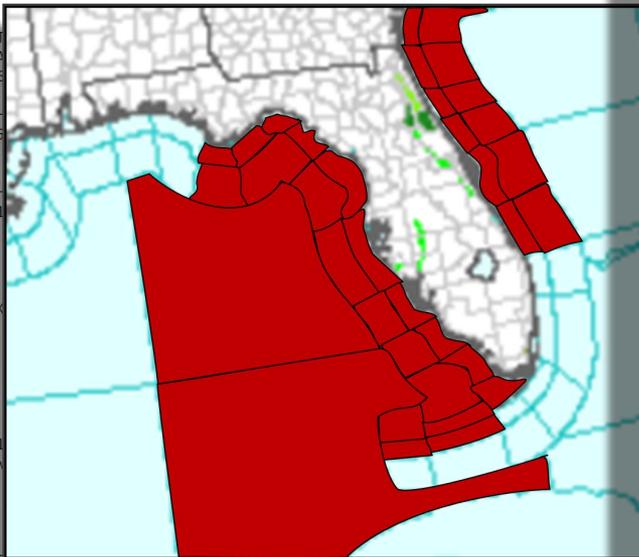
.COMPLEX LOW WITH MEAN CENTER 45N165W WITHIN 420 NM S AND SE QUADRANTS WINDS 40 TO 50 KT. ELSEWHERE FROM 30N TO 47N W OF 175W WINDS 25 TO 40 KT. SEAS 5 TO 8 M.

.24 HOUR FORECAST LOW ABSORBED BY 163E WINDS 35 TO 50 KT. SEAS 6 TO 10 M. .48 HOUR FORECAST LOW AND ASSOCIATED WINDS 35 TO 50 KT. SEAS 6 TO 10 M.

...STORM WARNING...

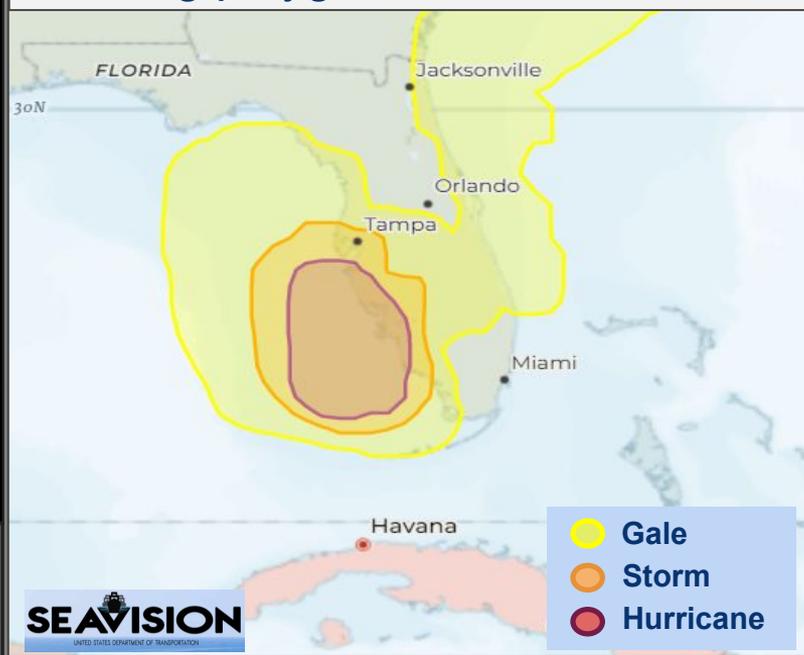
.COMPLEX LOW WITH MAIN CENTER 31N175W WITHIN 300 NM S AND SE QUADRANTS WINDS 35 TO 45 KT. ELSEWHERE FROM 30N TO 43N BETWEEN 173W AND 180W WINDS 25 TO 40 KT. SEAS 4 TO 7 M.

.24 HOUR FORECAST COMPLEX LOW WITH MEAN CENTER 30N175W WITHIN 300 NM S AND SE QUADRANTS WINDS 35 TO 50 KT. SEAS 4 TO 7 M. ELSEWHERE FROM 30N TO 35N BETWEEN 157W AND 179W WINDS 25 TO 35 KT. SEAS 3 TO 6 M.



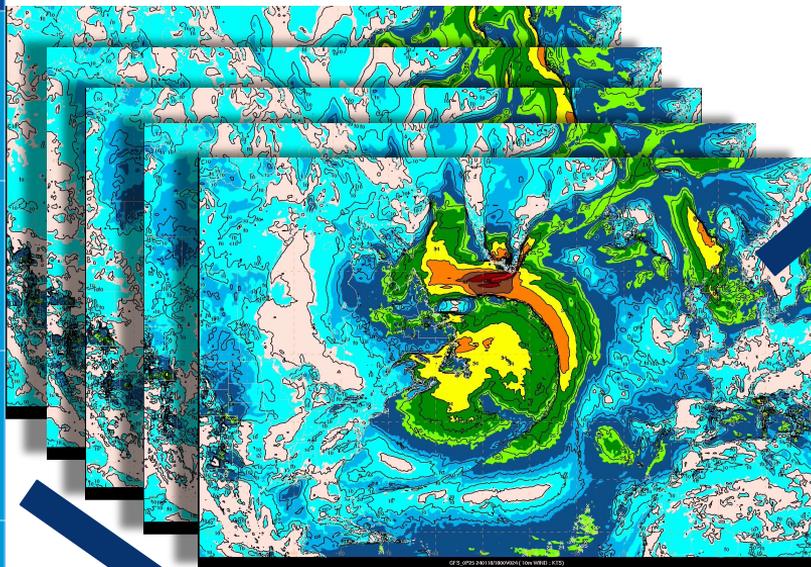
RED indicates Zones that have active warnings

Experimental condition-based wind warning polygons for Hurricane Ian



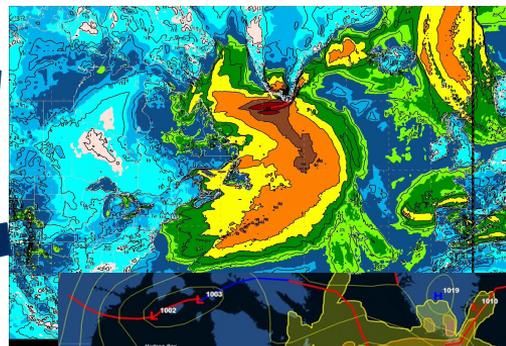
-  Gale
-  Storm
-  Hurricane

Derivation of S-412 Warning Polygons



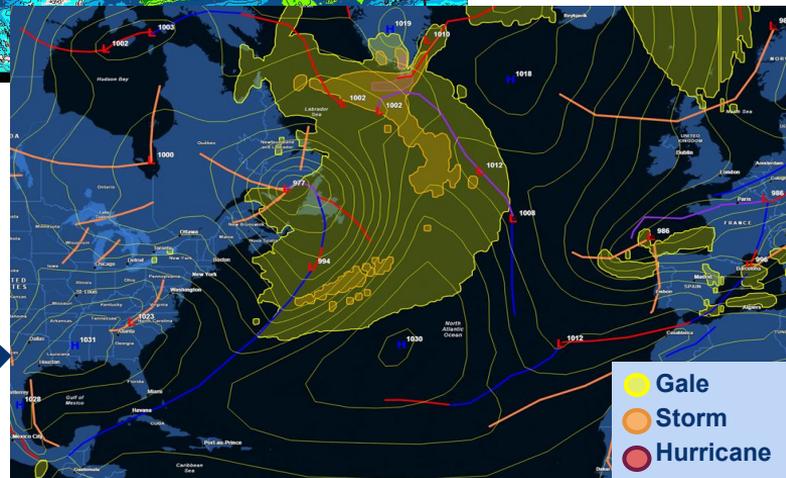
1. Composite Maximum Wind Speed values for each gridpoint from hourly time steps

2.



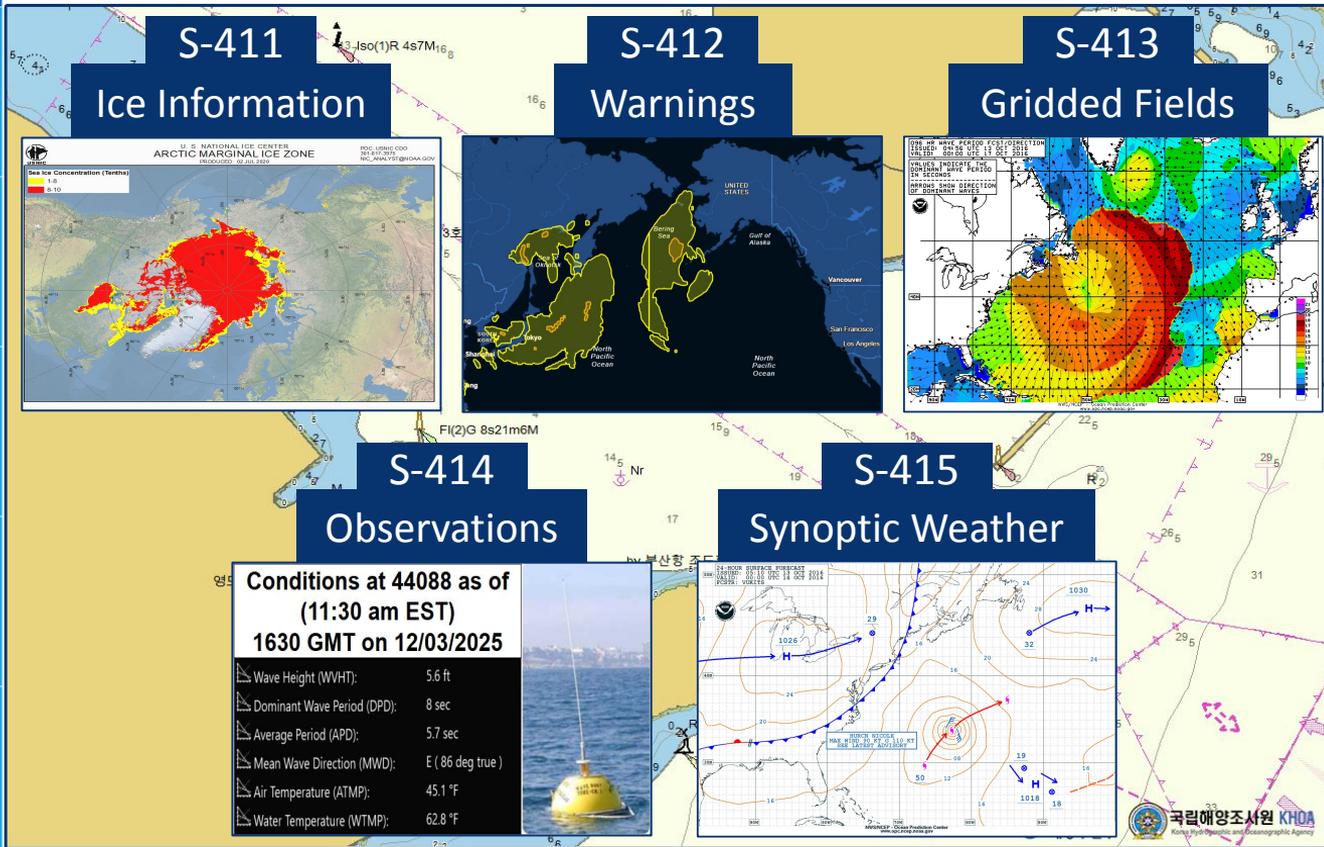
24-hour Composite of Maximum Wind Speed

3.



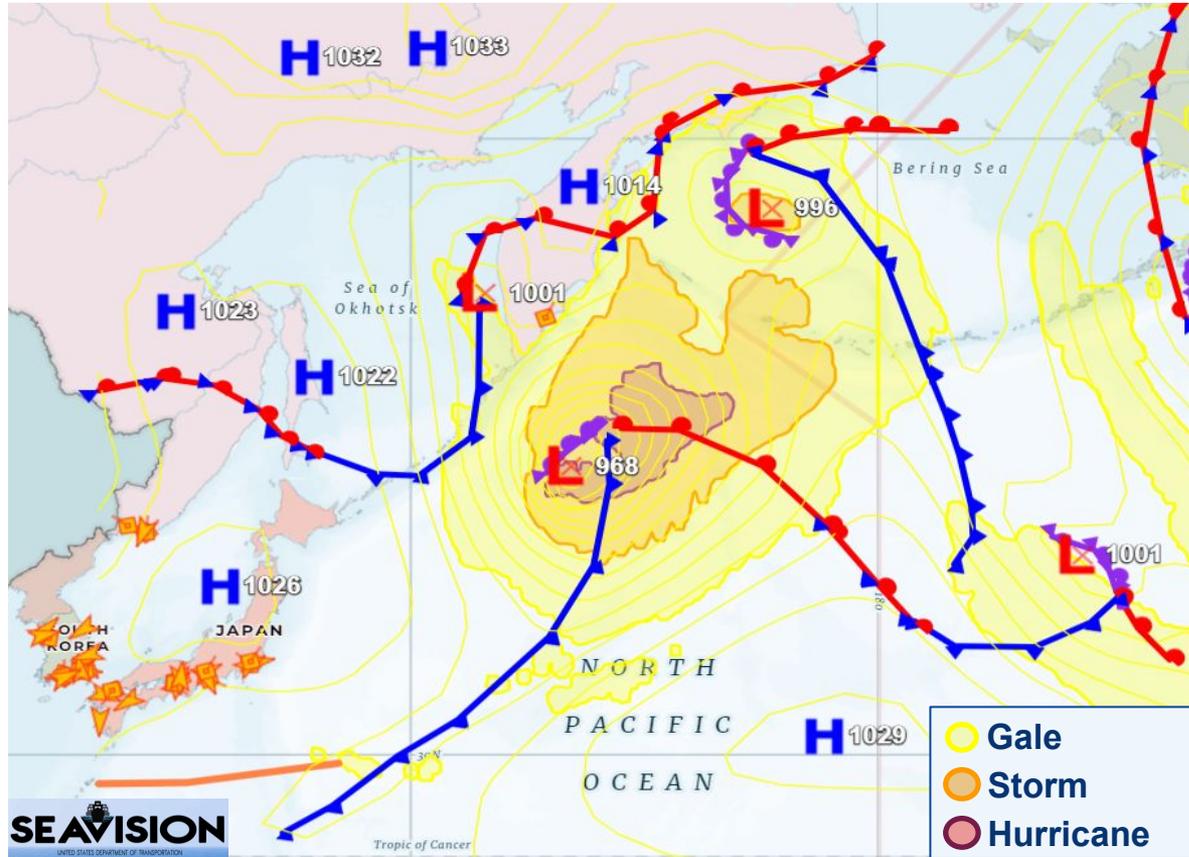
S-412 Wind Warning Polygons for ECDIS (GML format)

Seeing the Full Picture with S-41x





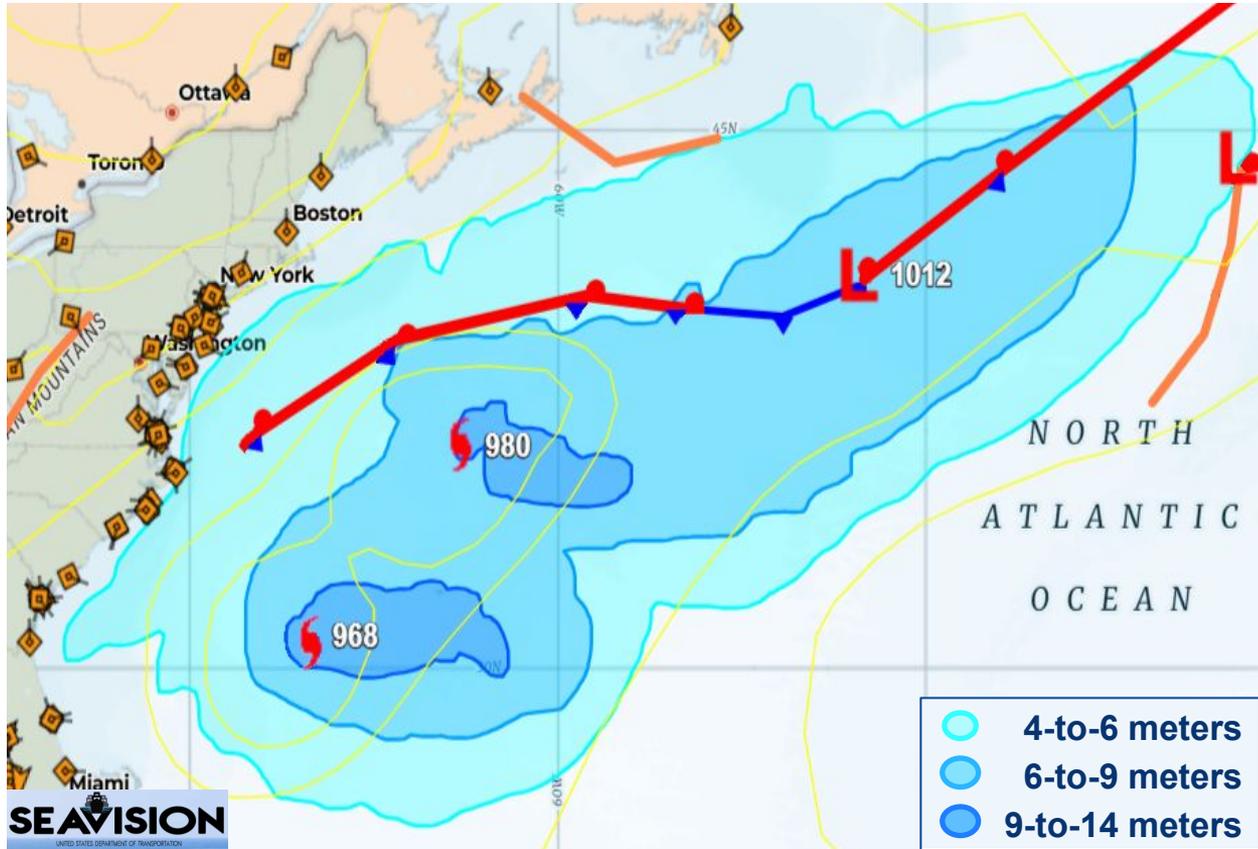
Complementary S-41x Overlays



S-412
Wind Warnings
&
S-415
Synoptic Weather
Features

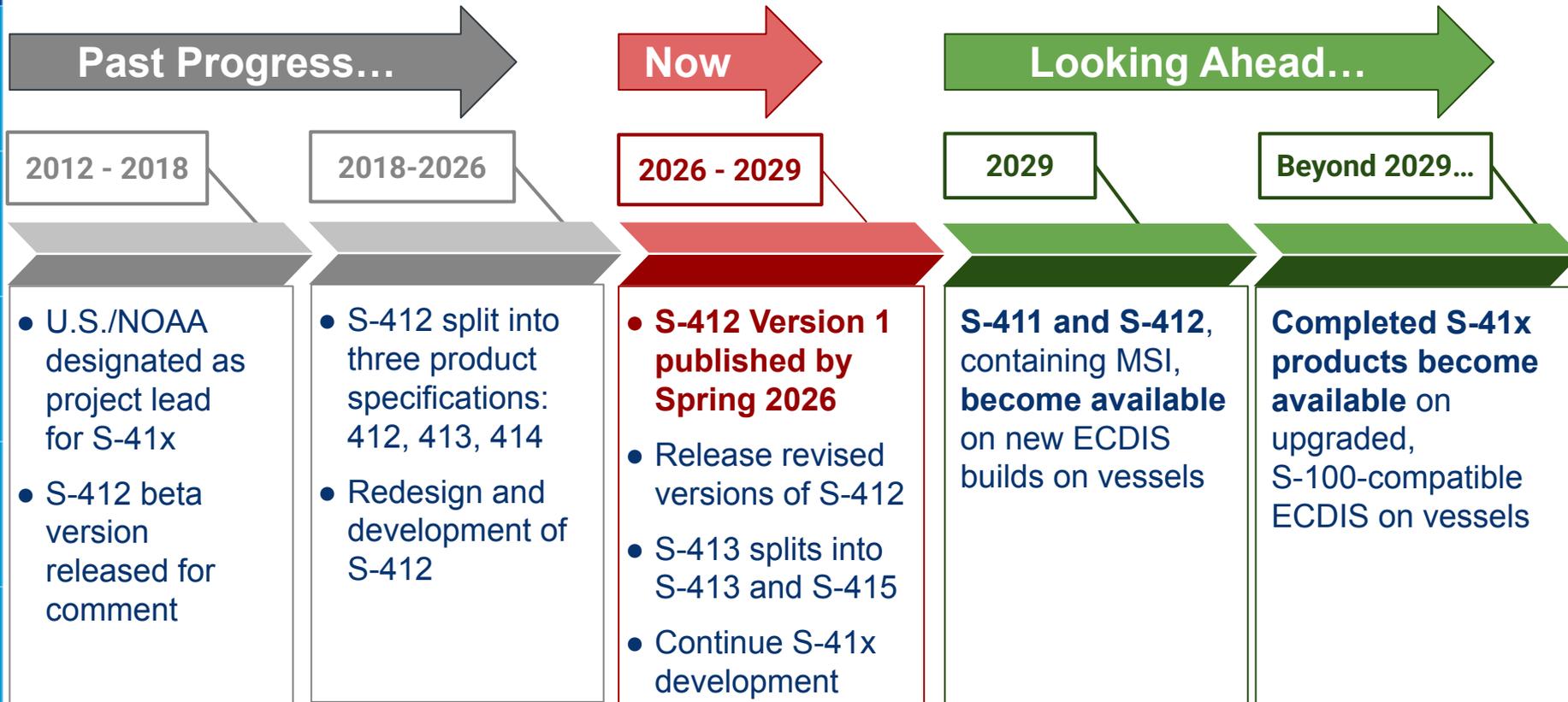


Complementary S-41x Overlays

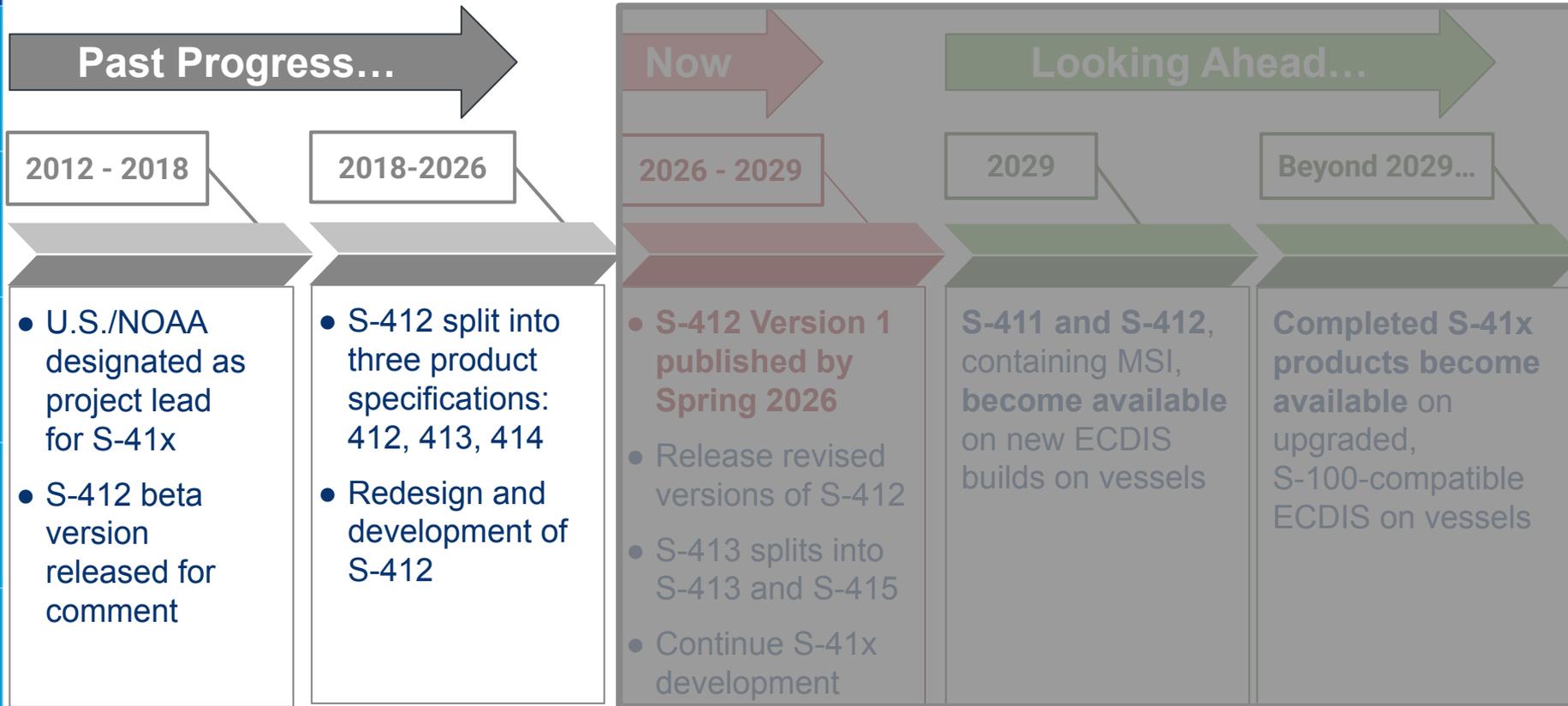


S-412
Significant Wave
Height Warnings
&
S-415
Synoptic Weather
Features

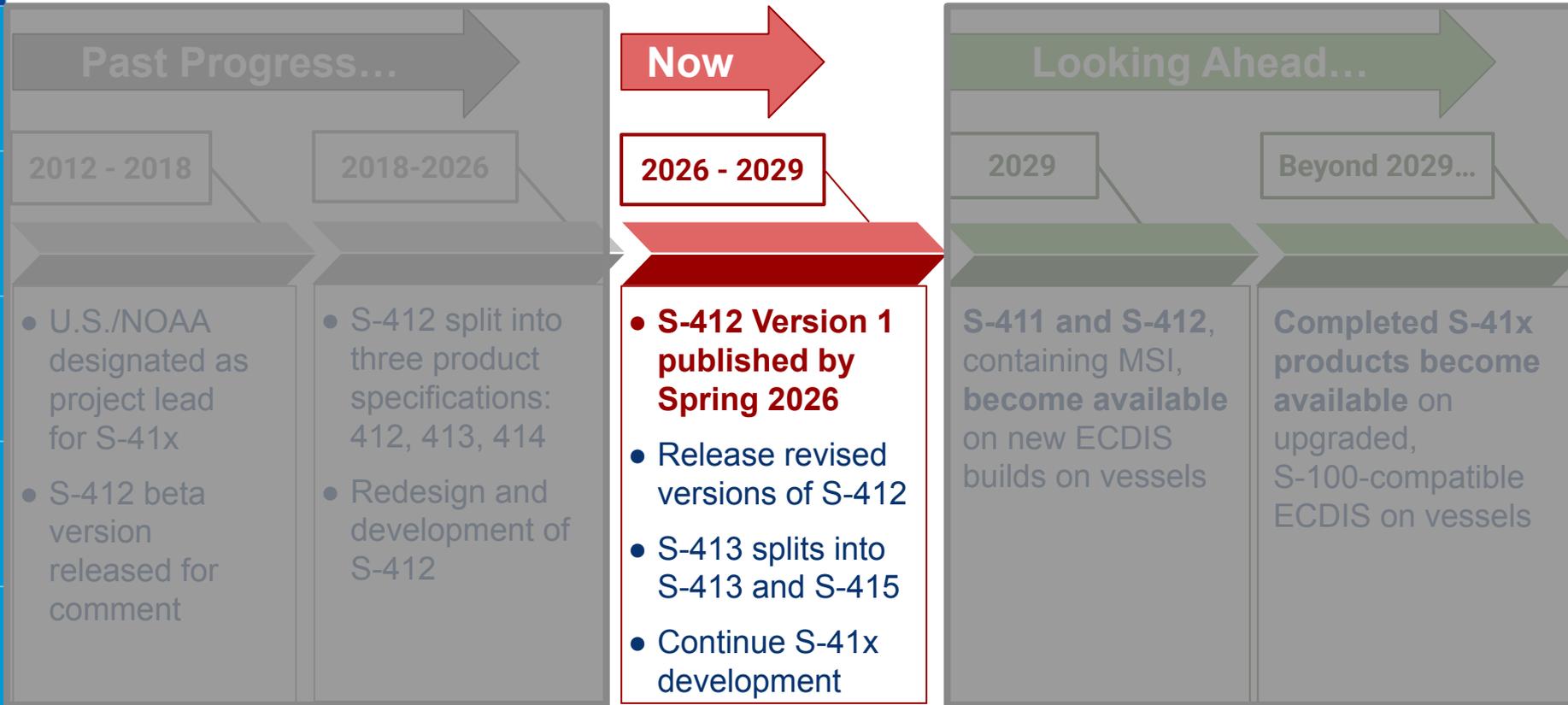
S-41x Project Timeline



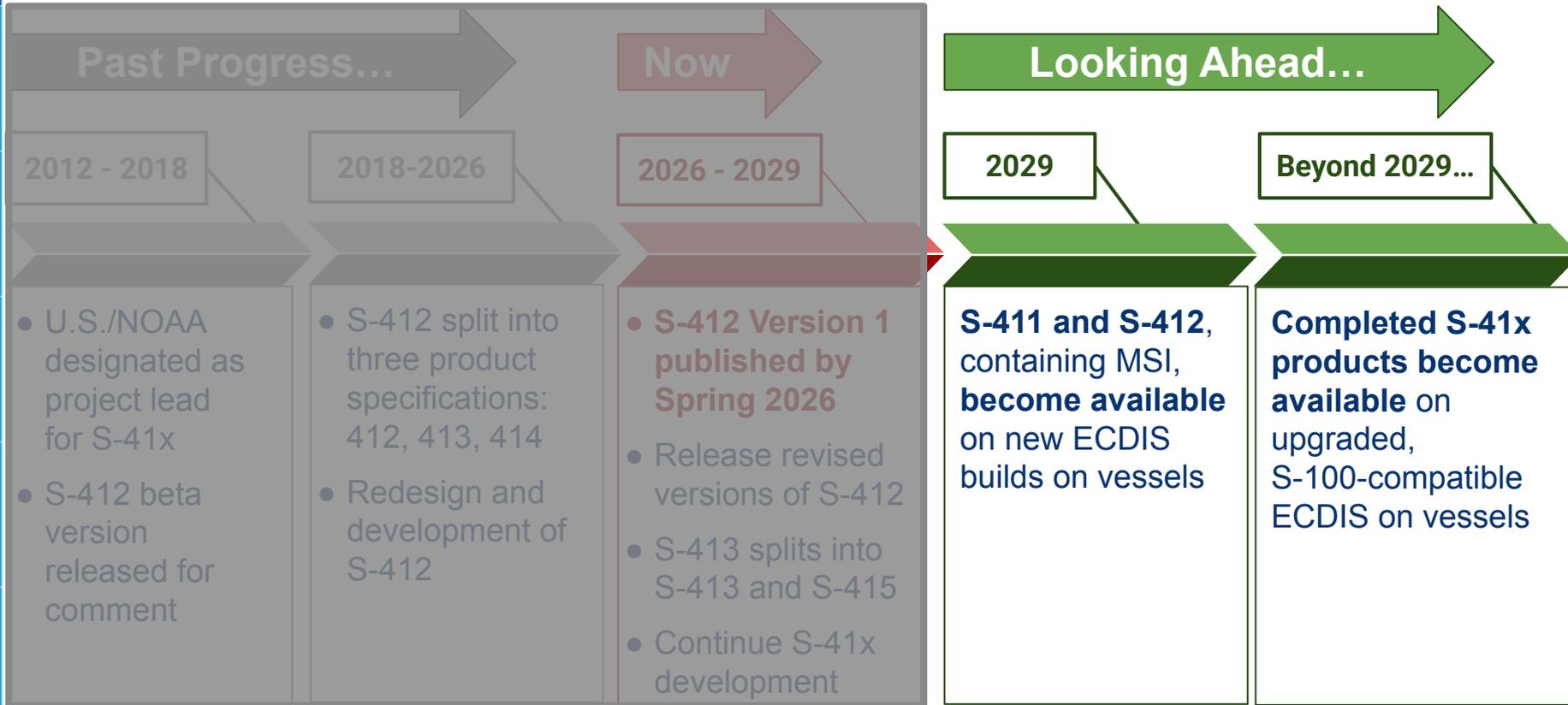
S-41x Project Timeline



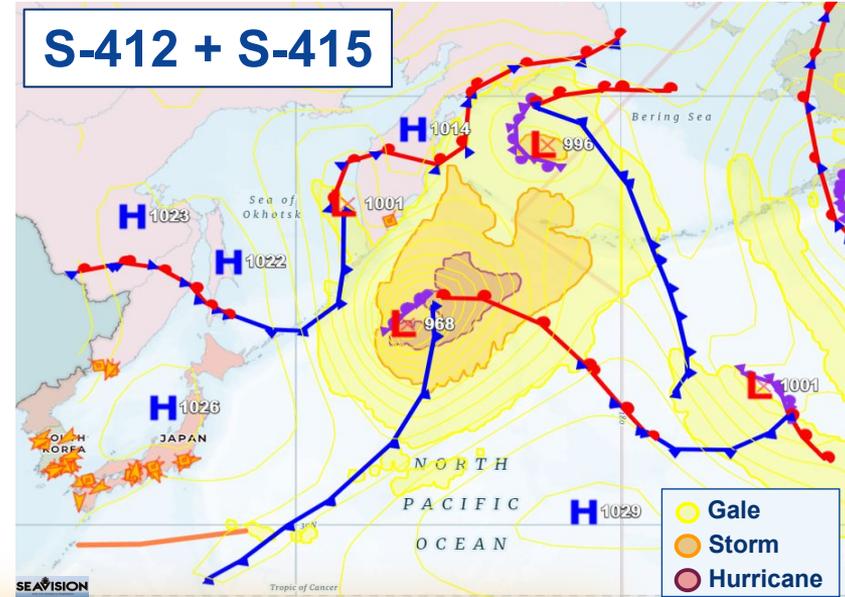
S-41x Project Timeline



S-41x Project Timeline



Charting the (Near) Future with S-41x



Safer navigation through harsh seas



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