



**Operations to Moving Helidecks**  
**Helideck Monitoring Systems**

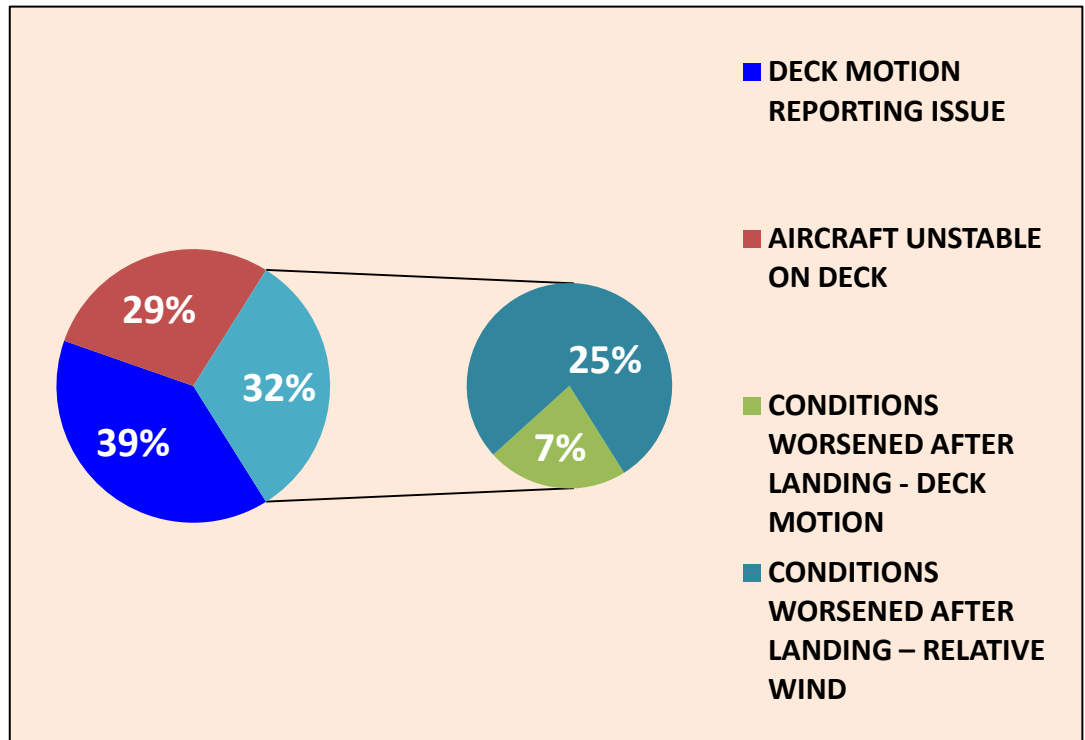
1<sup>st</sup> November 2017

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- Relative wind monitoring function
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# Background (1)

- Research launched in 1992 partly in response to fatal accident (HLO decapitated) on Mayo DSV.
- Further impetus added following accident on West Navion drill ship in 2001.
- Total of 28 MORs (as at 31 December 2016) comprising:
  - 3 accidents of which 2 resulted in fatalities;
  - 25 incidents.
- Three main issues identified:
  - deck motion reporting;
  - instability on deck;
  - conditions worsening after landing.



# Background (2)

- Main research effort has been directed at computer modelling of helicopter stability on moving decks.
- Modelling supported by:
  - Instrumented trials on Foinaven (S76) and at Aberdeen (AS332);
  - In-service trials on Maersk GPIII (Bond);
  - In-service trials on Chevron Captain (Bristow);
  - Validation against Flightlab model (by NLR).
- More work required but scheme considered mature enough for initial implementation.
- Future developments will very likely only affect helicopter limits which can be updated via internet.





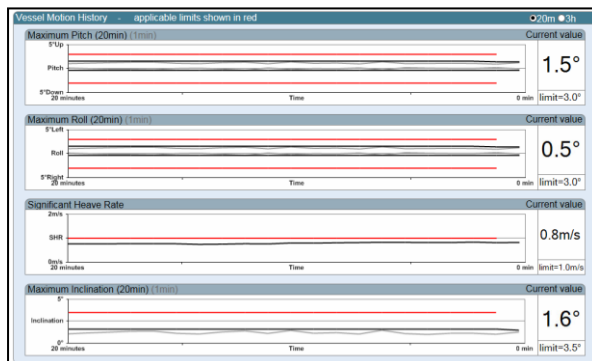
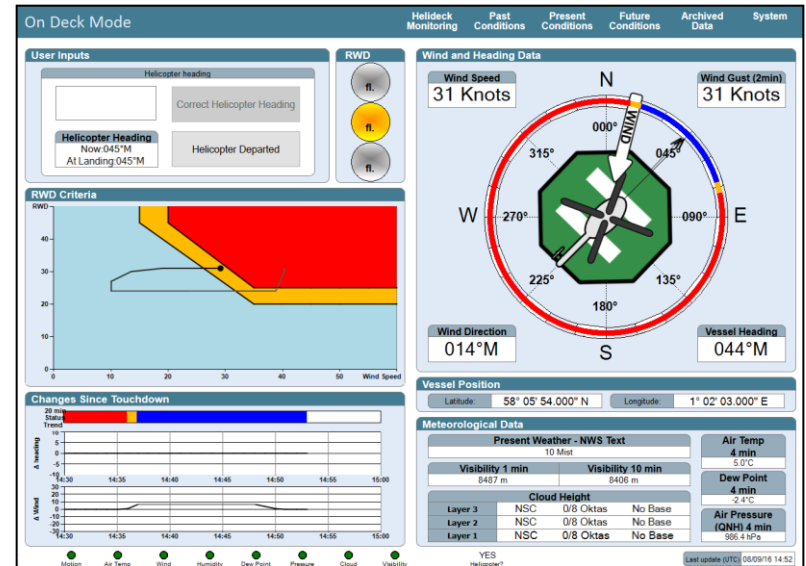
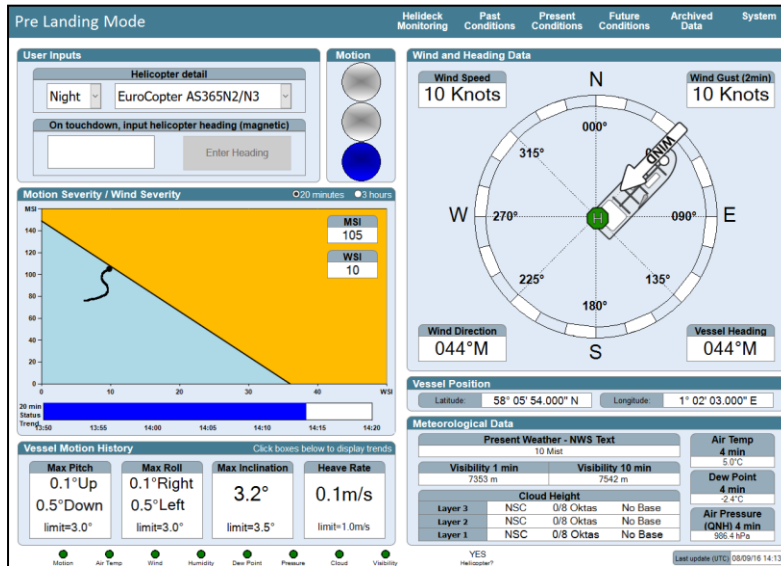
# Modifications to HMS

- Introduction of improved, 'standardised' system displays.
- Introduction of helideck motion status repeater lights.
- Move from 'Norwegian Method' (NM) to significant heave rate (SHR).
- Introduction of relative wind monitoring function.
- Introduction of MSI/WSI, initially on advisory only basis.

**NB: See later for how these modifications address the safety issues identified.**



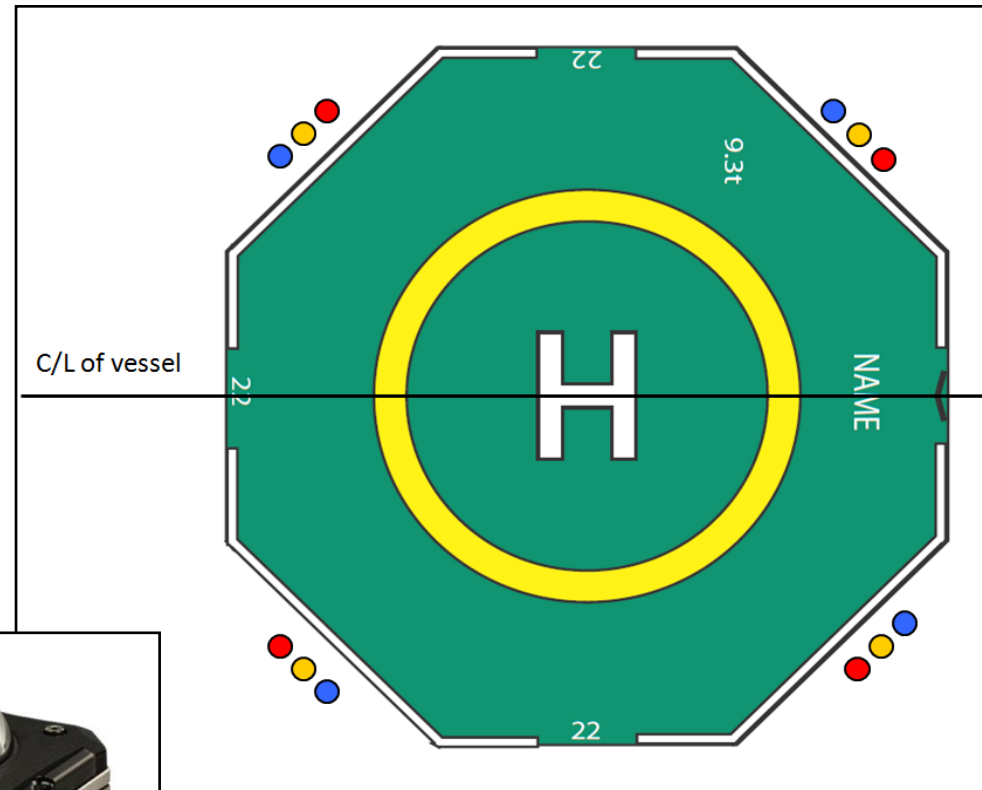
# Improved displays



- Designed based on human factors principles.
- Expected to reduce occurrences of misreporting of vessel motion.
- Internet access for flight crew.
- Greater standardisation.

# Helideck motion repeater lights (1)

- Helps to address up to 39% of in-service occurrences (misreporting of helideck motion).
- Enables relative wind monitoring function to be fully implemented which, itself, helps to address a further 25% of occurrences.
- Original 10cd lights not bright enough during the approach in daylight.



# Helideck motion repeater lights (2)




- Higher intensity lights based on Orga wave-off light produced.
- 3 intensity settings of 200cd, 400cd and 600cd evaluated by pilots at Aberdeen – 400cd selected (luminance similar to road traffic lights).
- Each light will:
  - generate all 3 colours
  - control mode (flashing/steady burning)
  - control intensity (day/night)
- Zone 2 certificated units produced for installation on 'Captain' and 'Alba' FSU by end 2017.





# Helideck motion repeater lights (3)


Pre landing:

-  = safe to land (ROLL, PITCH, INCLINATION and HEAVE RATE all within limits)
-  = land with caution/consider employing revised helideck handling procedures (MSI/WSI only out of limits)
-  = **do not land** (ROLL, PITCH, INCLINATION or HEAVE RATE out of limits)

# Helideck motion repeater lights (4)

After landing (helicopter heading reported to vessel and entered into HMS):

 = HMS in 'on-deck' mode, RWD within limits (slow flash )

 = RWD limit approaching - investigate (fast flash)

 = RWD limit exceeded - take action (fast flash)

# Helideck motion repeater lights (5)

- Interface with HMS via a simple 3-wire signal.
- Light to be extinguished in case of loss of signal from HMS or internal fault.
- How many lights can be inop? Will depend on location of failed light(s) and wind direction (and speed?).
- All lights to be extinguished in the event of HMS failure.

HMS Signal (24 vdc or volt free)			Repeater Light Mode	
Wire #1	Wire #2	Wire #3	Colour	Mode
0	0	0	OFF	N/A
0	1	0	BLUE	Steady burning
1	0	0	AMBER	Steady burning
1	1	0	RED	Steady burning
0	0	1	OFF	N/A
0	1	1	BLUE	Slow flash
1	0	1	AMBER	Fast flash
1	1	1	RED	Fast flash

# Significant heave rate

- Significant Heave Rate (SHR) is the average of the highest 1/3<sup>rd</sup> heave rate measurements during the monitoring period.
- For this application, this can be simplified to:

$$\text{SHR} = 2 \times \text{RMS heave rate over 20 mins}$$

- Avoids ambiguities in definition of 'Norwegian Method' (NM).
- Overcomes problems of calculating heave period needed for NM.
- Results similar to NM so no need to change present heave rate limits.
- Solution to helideck motion status 'flicker' established and tested on data from Foinaven FPSO and data from a smaller vessel with shorter motion period.
- Already in CAP 437, but will allow to be deferred and included with overall upgrade.

# Relative wind monitoring function (1)

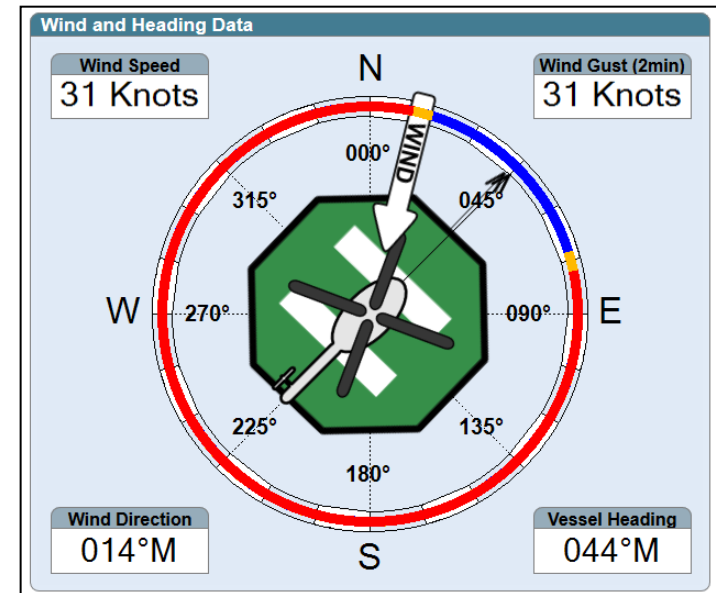
- Helps to address West Navion accident scenario and line squalls.
- Next to rotors on/off, relative wind direction is the most significant parameter affecting on-deck stability.
- Initial scheme using 2 minute average wind direction trialled on GP III and no problems identified.
- Need short averaging period for quick response to wind direction changes, but...
- Problem of spurious warnings due to natural variability in wind if averaging period too short.
- No change to averaging period following GP III trials.





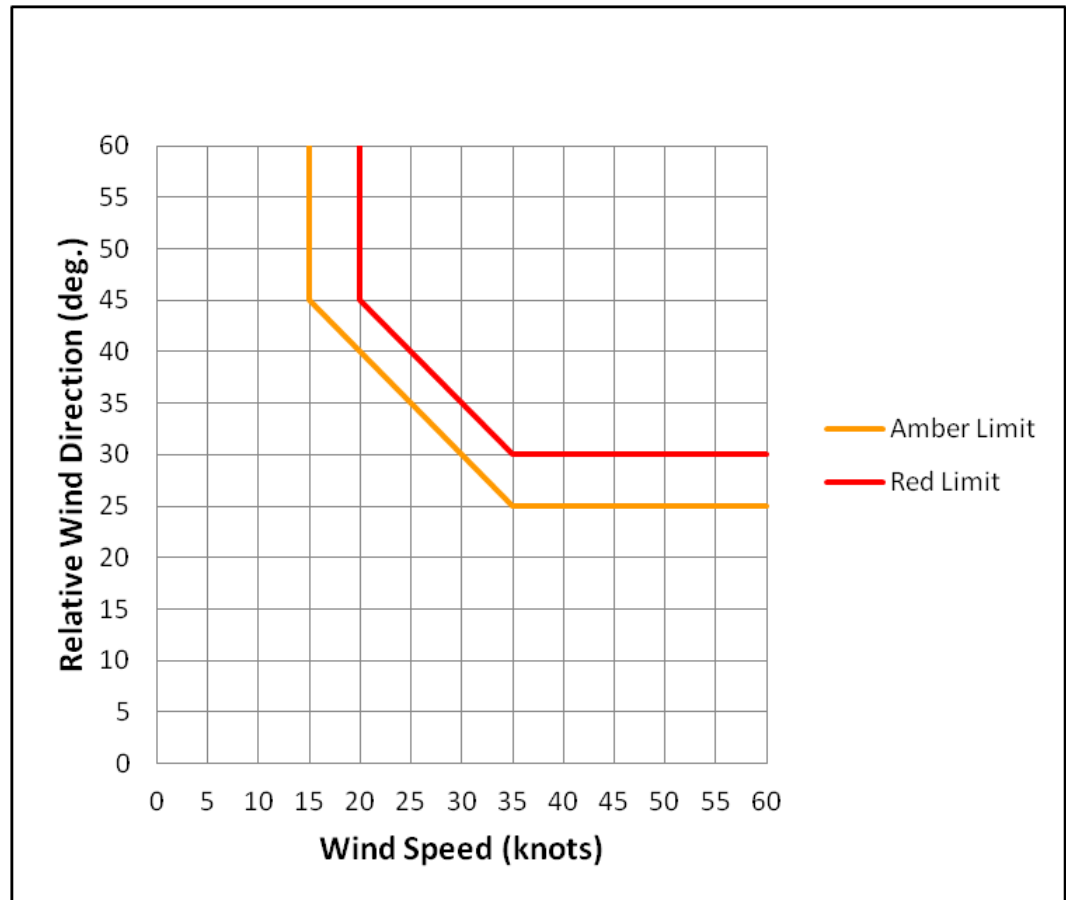
# Relative wind monitoring function (2)

- Relative wind direction depends on:
  - alignment with wind at touchdown,
  - variation in wind direction after landing, and
  - variation in vessel heading after landing.
- Assume relative wind at touchdown:
  - <30 deg. at low (<15kts) wind speeds,
  - <10 deg. at high (>35kts) wind speeds,
 based on advice from helicopter operators and supported by results from GPIII trial.
- Variation in wind direction derived from Frøya data (10 year sample).
- Variation in vessel heading initially estimated from experience with trials vessels – subsequently found to be unrepresentative for vessels without heading control (e.g. ‘Alba’ FSU); adjusted to cover for the time being but may need two different limits.



# Relative wind monitoring function (3)

- Relative wind limit set to 'contain' 95% of expected variability.
- Limit expected to be exercised in the event of line squalls, vessel heading control system defects and any other unpredictable 'events'.
- RED** limit linked to calculation of MSI/WSI limit curve.
- AMBER** limit provides 5 kts/5 deg. advance warning.



# MSI / WSI (1)

- Motion Severity Index (MSI):
  - The MSI is the 20-minute maximum value of the measure of motion severity (MMS), given by:

$$MMS = \frac{\left| \begin{matrix} \vec{x}_{ddot} + \vec{y}_{ddot} \\ \vec{z}_{ddot} \end{matrix} \right|}{\left| \vec{z}_{ddot} \right|} = \frac{\sqrt{\left( \left| \vec{x}_{ddot} \right| \right)^2 + \left( \left| \vec{y}_{ddot} \right| \right)^2}}{\left| \vec{z}_{ddot} \right|}$$

i.e. the MMS is the acceleration in the plane of the helideck divided by the acceleration normal to the helideck (including gravity).

- The MSI describes the severity of deck motion based on helideck accelerations, measured nominally at the centre of the deck by a 3-axis accelerometer package.
- The arctangent of the MSI is effectively the dynamic helideck slope, i.e. the actual inclination of the helideck plus an additional allowance for accelerations due to helideck motion. With no motion, the arctangent of the MSI will be equal to the deck inclination.

## MSI / WSI (2)

- Wind Severity Index (WSI):
  - The WSI provides a measure of wind speed which is used as a reference when quantifying the aerodynamic loads on the helicopter due to main and tail rotor forces and moments and due to drag.
  - The WSI is defined as the 10-minute mean wind speed corrected to deck height + 4m, i.e. approx. main rotor height.

$$\text{WSI}(t) = \text{mean}_{t-10\text{min}} (U_{\text{meas}}) \cdot \left( \frac{H_d + 4\text{m}}{H_{\text{meas}}} \right)^{0.13}$$

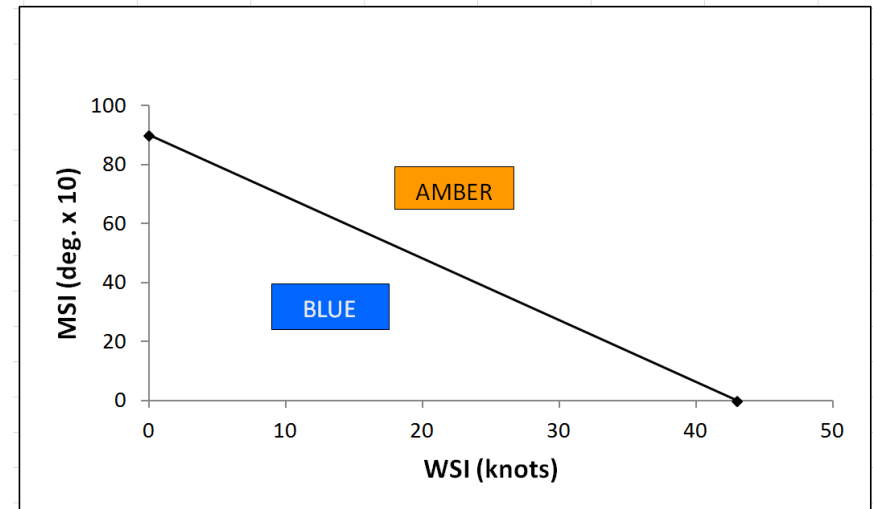
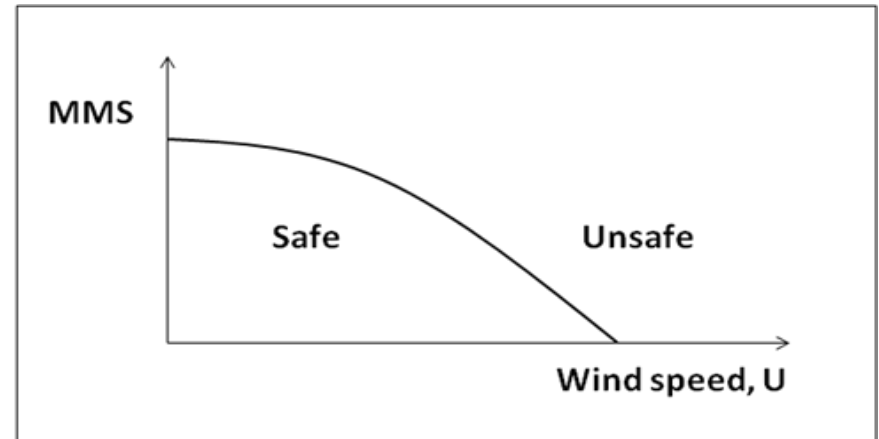
where:  $H_d$  is the helideck height in metres

$U_{\text{meas}}$  corresponds to the measured wind speed at a height  $H_{\text{meas}}$

- An allowance for updrafts and gusts is made in the computer modelling used to derive the operating limits as a function of WSI.

# MSI / WSI (3)

- MSI/WSI limit curves derived using computer model and Monte-Carlo simulation.
- Model not yet fully validated but considered fit for purpose.
- Need to consider tipping and sliding failure modes – limit defined by whichever failure mode occurs first.
- Limits are helicopter type specific – initial generic limit based on assumed worst case (Super Puma) and based on tipping failure only.
- Limit curve implemented as a straight line for simplicity (likely to be conservative).
- $MSI_{max} = 91$ ,  $WSI_{max} = 43$  kts.





# MSI / WSI (4)

- **AMBER** advisory only, i.e. consider using modified deck operating procedures.
- Addition of MSI/WSI can only increase safety if existing P/R/INC/HR limits retained.

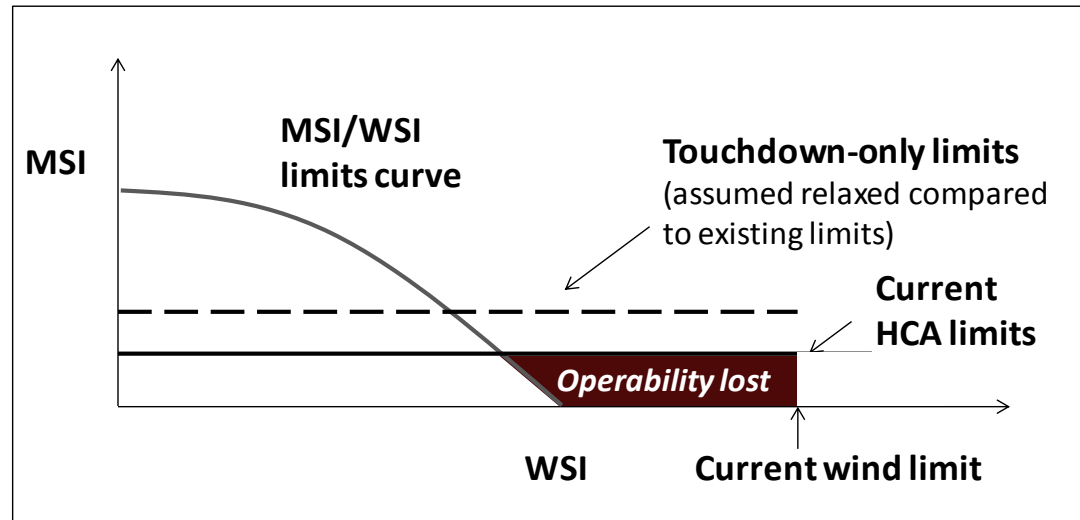
## **Modified deck handling guidance for “steady amber” deck motion light (MSI/WSI exceedence)**

The following should be **considered** when operating on an offshore installation in steady amber conditions, in order to minimise time on-deck and to maximise A/C weight:

- At touchdown, take particular care to align the aircraft with the wind.
- Both pilots to remain at the controls during re-fuelling, embarking/disembarking of passengers, bags and freight. If any of the crew members requires a ‘comfort break’ then this should be taken after all turn-around activities have been completed and the A/C confirmed as secure.
- Swapping embarking/disembarking passengers one or two at a time.
- If necessary, refuel with passengers on board to maintain A/C weight as high as possible.
- Carry out one operation at a time.

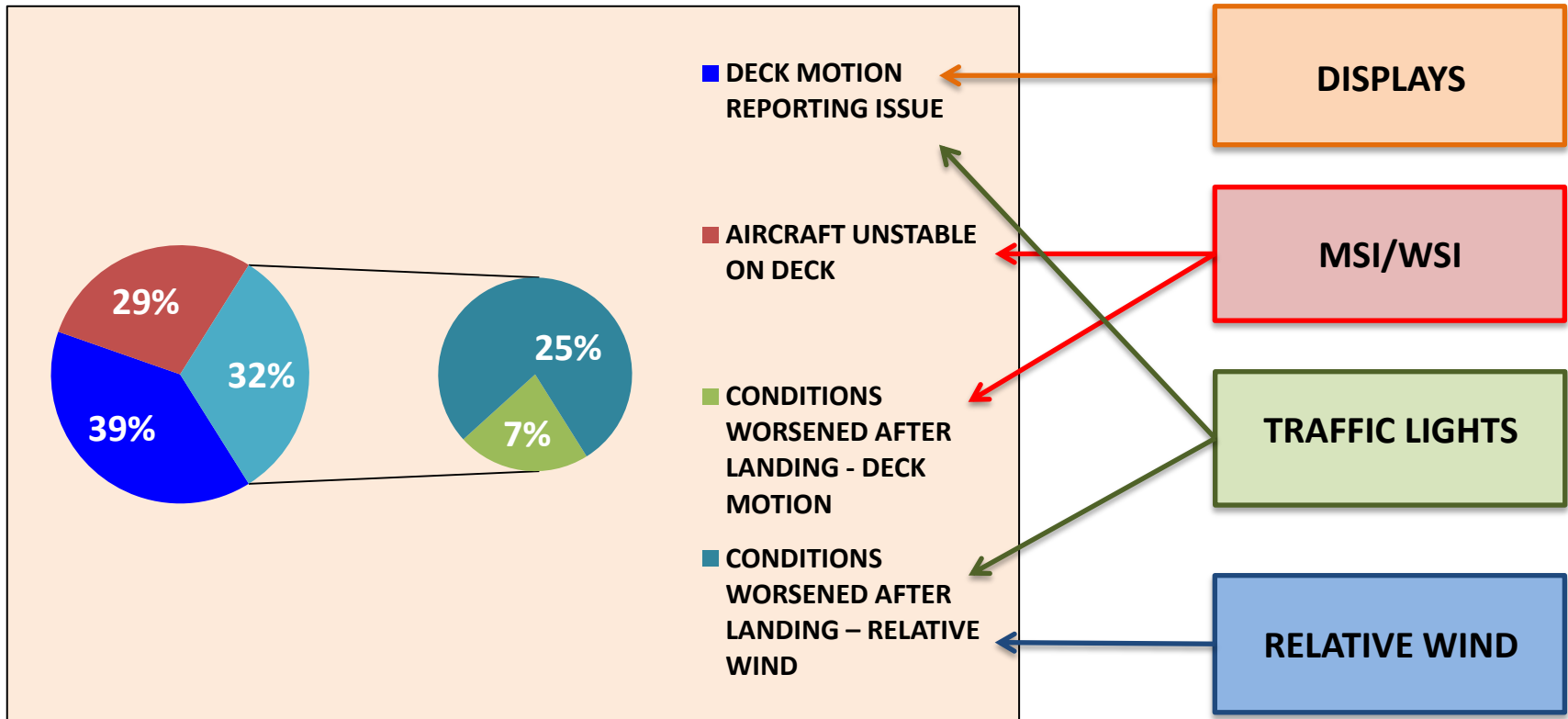
Any number of the above may be selected by the pilot depending on the prevailing conditions, but pilot to make clear to the HLO in advance exactly what course of action is to be taken to prevent any confusion.

# MSI / WSI (5)



- Further work on MSI/WSI limits planned:
    - refinement of wind/gust prediction aspects;
    - production of helicopter type-specific limits.
- NB: Limits can be added / modified by HMS software update via internet.
- **RED** MSI/WSI do not land limits will need to be helicopter type specific, validated and included in Rotorcraft Flight Manual.
  - **RED** MSI/WSI limits required if existing P/R/INC/HR limits relaxed to improve operability, i.e. credit taken for MSI/WSI.

# Addressing the Problems



# Timescales

- HMS software:
  - Software installed on Chevron 'Captain' and 'Alba' FSU.
  - Minor updates (to limits) required prior to restart of in-service trials.
- Traffic lights:
  - Installation of Zone 2 certificated units by end 2017.
  - Swap out with Zone 1 units (if required) following confirmation of specification.
- In-Service trials:
  - Restart following software update and installation of traffic lights.
  - Expected Q4 2017 / Q1 2018.
- Implementation:
  - Finalise and publish (HCA) new HMS specification following confirmation from in-service trials.
  - Update CAP 437 early 2018.
  - Allow 3-year (?) lead-in; stable deck landings only after lead-in period if not implemented.

Thank you for your attention...

**Any questions?**