SAFETY SERVICES ORGANISATION

HAZ ID AND HAZ OP

HAZARD IDENTIFICATION – TECHNIQUES

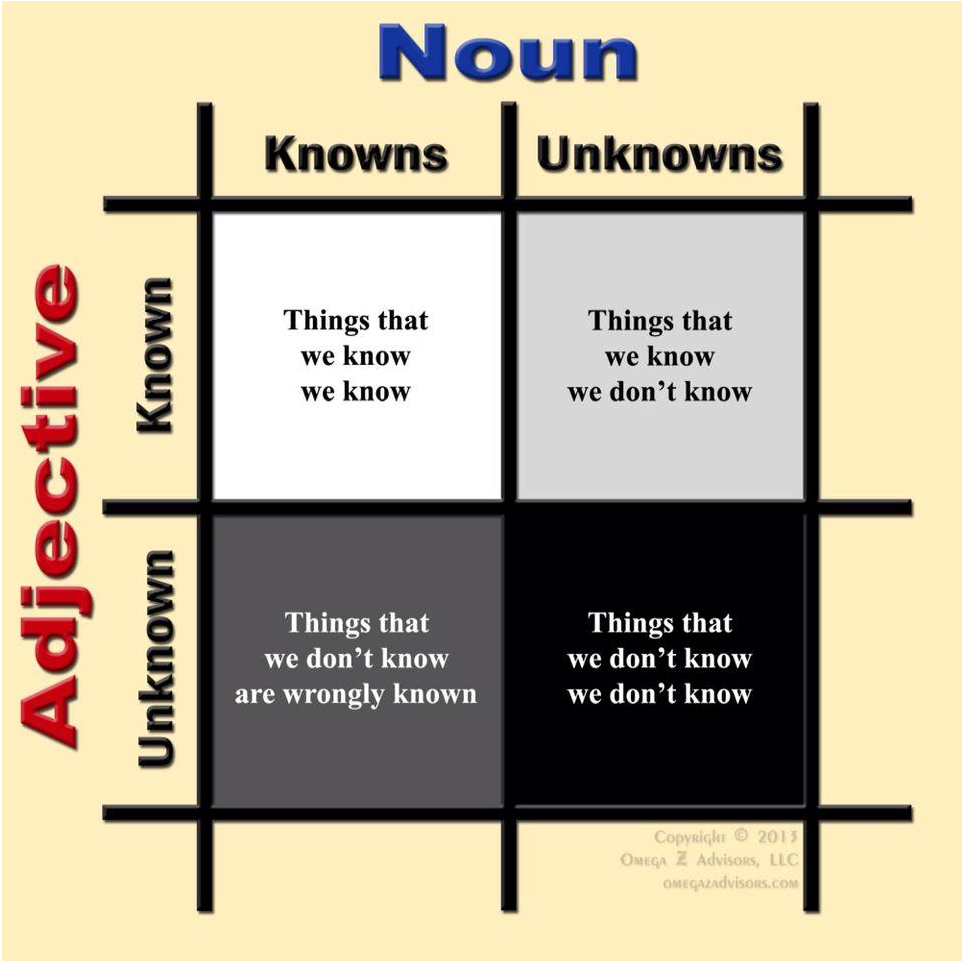
CONTENTS - TECHNIQUES FOR HAZ ID

Methods for Haz ID:

- Why these techniques?
- Hazard Checklist
- Accident and History Review
- Structured What If Technique (SWIFT)
- Failure Modes and Effects Analysis (FMEA)
- Zonal Hazard Analysis (ZHA)
- Hazard and Operability Study (Haz Op) – Next Lecture

[5,6]

WHY?



Missing a Hazard at the Haz ID stage, means you carry unknown unknowns throughout the project. This is your best chance to eliminate them, without expensive reworking. That is why this phase is focussed on systematic techniques.

HAZARD CHECKLIST DESCRIPTION

A Hazard Checklist contains questions or topics designed to provoke consideration of safety issues when looking at a system, equipment or item.

Generally better at identifying physical, rather than functional hazards.

When setting up and using a Hazard Checklist, the following points should be considered:

- A Hazard checklist should not generally be the only HAZID method.
- The topics presented in any Hazard Checklist should not be considered to be comprehensive.
- Hazard checklists should be applied in an imaginative way by those with a good understanding of the system.

[2,7,8]

HAZARD CHECKLIST EXAMPLE

An example of a Hazard Checklist from the Aviation domain (ASEMS).

For OME, the AOP-15 questionnaire used to generate the MTDS can be used (discussed in the previous lecture).

Hazard category	Key hazards assigned to hazard category
1. Fire	• Fire
2. Explosion	• Explosion
3. Disruption	• Structural break up • EMC • Deliberate 3rd party • Incompatibilites (procedures/interoperability)
4. Human performance	• Design performance and handling characteristics of aircraft and systems in the air or on the ground. • Crew incapacitation • Congestion • Inappropriate competence • Inexperience • Inappropriate/Inadequate communication • Inadequate procedure • Unfit for duty • Lack of currency • In-discipline • Inadequate supervision • Human capacity Workload
5. Operating hazard	• Natural operating hazards • Man-made operating hazards • Inadvertent 3rd party
6. Survival	• Post-accident survival
7. Environment*	• Noise • Vibration • Hazardous materials • Pollution • Emissions

[7,9]

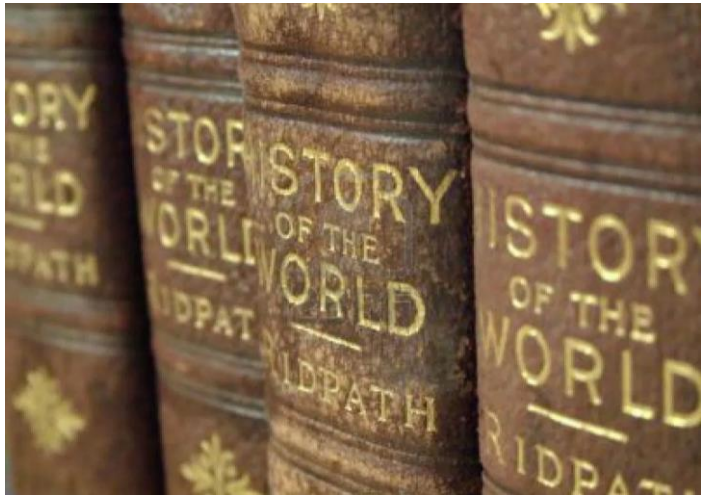
HAZARD CHECKLIST – PROS AND CONS

Advantages

- Makes use of experience from previous risk assessments. Helps to prevent past accidents from recurring.
- Supports rapid Haz ID of similar systems.
- Can be done by a single analyst at low cost.
- Requires minimal information about the installation.

Disadvantages

- Limited to previous experience.
- Bounded in nature and thus does not encourage imaginative thinking.



[7,10,11]

HAZARD CHECKLIST – EXERCISE (PAVEWAY IV)

Hazardous components:

- Flammable substances; e.g. solid, liquid or gaseous;
- Lasers;
- Explosives;
- Electrical sources;
- Ionising and non-ionising radiation sources;
- Hydraulic arms or rotational machinery;
- Other energy sources including those due to motion;
- Exhaust gases;
- Cut and puncture projections.

Factors due to the operating domain e.g.:

- Drop;
- Shock and vibration, including seismic;
- Extreme temperatures, pressures and climatic conditions;
- Noise;
- Exposure to toxic or corrosive substances;
- Fire or explosion;
- Insect, rodent or mould damage;
- Foreign bodies and dust;
- Electrostatic discharge including lightning;
- Electromagnetic interference;
- Ionising and non-ionising radiation, including laser radiation;
- Faults in supporting systems; e.g. power supplies, hydraulic systems;
- Exhaust gases.

ACCIDENT & HISTORY REVIEW DESCRIPTION

A very simple technique which involves reviewing accident and near miss data of similar systems.

Can then be used to determine the actual hazards that will be experienced when in service.

Clearly it depends upon:

- The similarity of the systems
- The quality of the accident data
- The likelihood of occurrence of the particular accident/near-misses

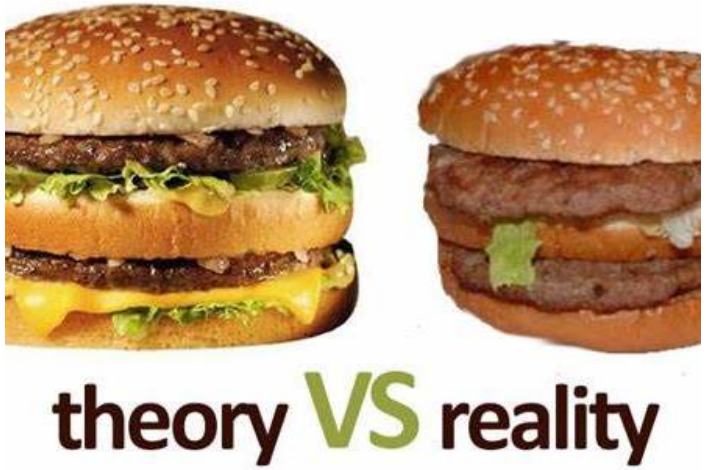
A useful technique, but should never be the only technique used and should not be relied upon to completely identify the hazards.

[7,12,13]

ACCIDENT & HISTORY REVIEW-PROS & CONS

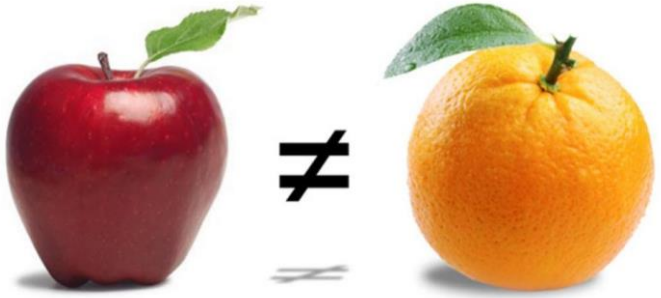
Advantages

- Quick and easy to do.
- Can give ‘actual’ hazards and risks.



Disadvantages

- Dependent on the quality and completeness of your accident data.
- Dependent upon the similarity of the systems.
- Unlikely to give information on low probability events, which can be the most severe.



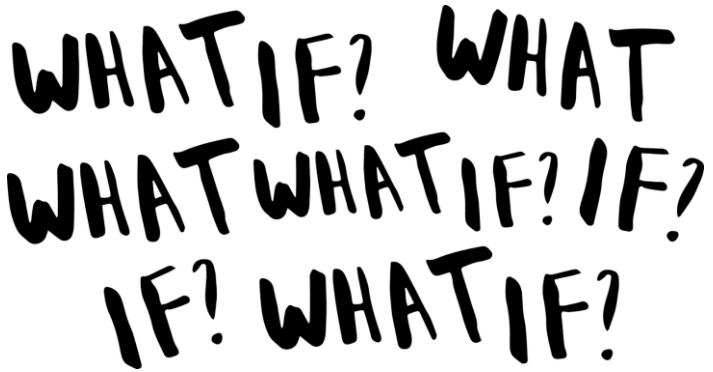
[7,14,15]

SWIFT DESCRIPTION

Structured **W**hat **IF** **T**echnique – SWIFT

- Combines the use of a checklist with a brainstorming approach.
- Developed as an efficient alternative to HAZOP.
- The technique essentially works by the leader asking the group to consider "what if's".
- The group will then brainstorm, before going on to answer those questions.

"What if?", "How Could?", "Is it possible?", "What would?" – all are acceptable.



[7,20,21]

CONDUCTING A SWIFT

Below are broad steps to follow when conducting SWIFT:

- Select a team.
- The leader should then prepare the checklist.
- At the beginning of the session the leader should brief the team and ‘set the scene’.
- Then the leader will go through the categories and ask the team to identify as many “what if’s” as they can.

[7,8,22]

CONDUCTING A SWIFT - CONTINUED

Below are broad steps to follow when conducting SWIFT:

- Once all the “what if’s” have been posed and recorded, the leader will refer to their checklist to ensure no areas of discussion have been missed.
- Next, the leader will ask the team to go through each of the questions and answer them.
- The session is then recorded on a log sheet by the technical recorder.

[7,8,22]

SWIFT CATEGORIES

The original SWIFT structure for questioning (based on the process industry):

- Material Problems (MP).
- External effects or influences (EE/I).
- Operating errors and other human factors (OE&HF).
- Analytical or sampling errors (A/SE).
- Equipment/instrumentation malfunction (E/IM).
- Process upsets of unspecified origin (PUUO).
- Utility failures (UF).
- Integrity failure or loss of containment (IF/LOC).
- Emergency operations (EO).
- Environmental release (ER).

Depending on the system under discussion, this list can be adapted as required.

SWIFT EXAMPLE

An example of a SWIFT Log Sheet from the Maritime domain (ASEMS).

Project: Fuel Transfer System			**Node:** 001		**Page:** 2
Node Description: Ship to Ship Fuel Transfer Operation					
Question Category	**What If**	**Consequences**	**Safeguards**	**Rec#**	**Recommendation**
External Factors or Influences	Heavy sea.	Potential collision between tanker and receiving ship.	Transfer is not carried out in > force 4. A gap of 50 metres is maintained between the ships during transfer.		
Operating Errors and other Human Factors	Operator connects up to thw wrong tank on the receiving ship.	Possible overfill of ship storage tank.	Operator training and competence.	R1	Ensure that destination fuel tank is correctly configured before starting transfer. This should be independently checked.
Loss of integrity	Hose ruptures	Discharge of fuel on tanker or receiving ship. Potential fire and pollution incident.	Inspection and testing of hoses. Visual inspection before use. 6 monthly test as part of planned maintenance. Operator can stop the transfer pump locally and isolate using the manual valves.	R2	Provide actuated valves on the fuel delivery and receipt points (i.e. on each ship) such that the fuel supply can be quickly isolated in the event of a spill.
	Pump casing fails due to cold weather.	Discharge of fuel on tanker. Potential fire and pollution incident.	Annual pump inspection.	R3	Check that fuel transfer pumps are not cast iron (cast iron pumps have been found to crack in cold weather). If the pump is cast iron it should be replaced.
Emergency Operations	Tanker or ship has to manoeuvre in emergency.	Possible hose rupture and discharge of fuels (fire and pollution incident).	Tanker and/or receiving ship would instruct for hoses to be disconnected before manoeuvring.	R4	Review the design of the hose connections and if necessary modify so that hoses can be quickly disconnected if needed in an emergency.

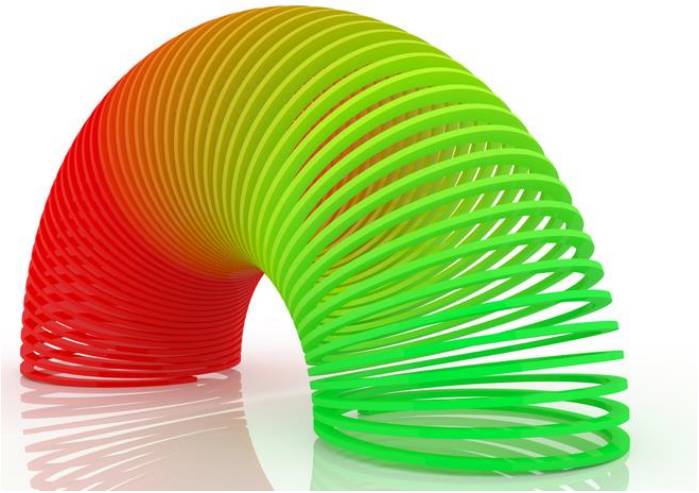
SWIFT – PROS AND CONS

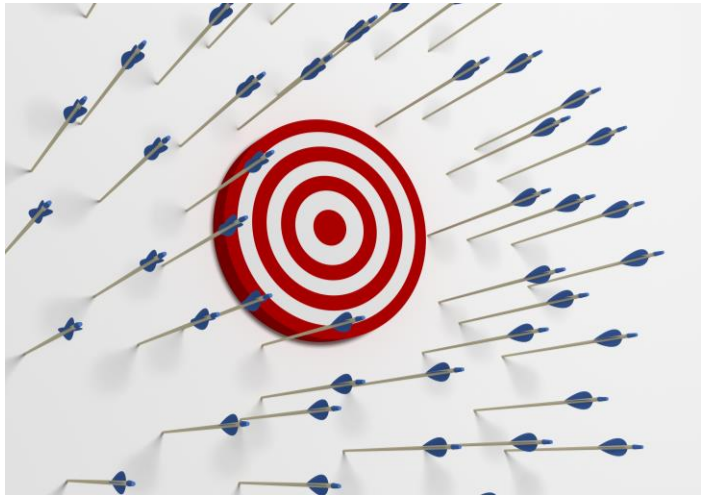
Advantages

- Quick and efficient
- Much more flexible than other techniques
- Is able to utilise lots of experience within the team.
- The checklists are robust.

Disadvantages

- The effectiveness is dependent upon adequate preparation of the checklist, experience of the leader, and knowledge of the team.
- It relies on how well the session goes. Reviewing the completeness of a SWIFT session is difficult.
- Doesn't apply itself well to quantitative analysis.





[7,23,24]

SWIFT – EXERCISE (4.5-INCH MK 8 NAVAL GUN

- Material Problems (MP).
- External effects or influences (EE/I).
- Operating errors and other human factors (OE&HF).
- Analytical or sampling errors (A/SE).
- Equipment/instrumentation malfunction (E/IM).
- Process upsets of unspecified origin (PUUO).
- Utility failures (UF).
- Integrity failure or loss of containment (IF/LOC).
- Emergency operations (EO).
- Environmental release (ER).

[7,30]

FMEA/FMECA DESCRIPTION

Failure **M**odes and **E**ffects **A**nalysis – FMEA.

This ‘bottom up’ technique involves looking at individual components or functions and asking the following questions:

- How can each component/function fail?
- What might cause these modes of failure?
- What could the effects be if these failures did occur? How serious are these failure modes?
- How is each failure mode detected?
- What are the safeguards in place?

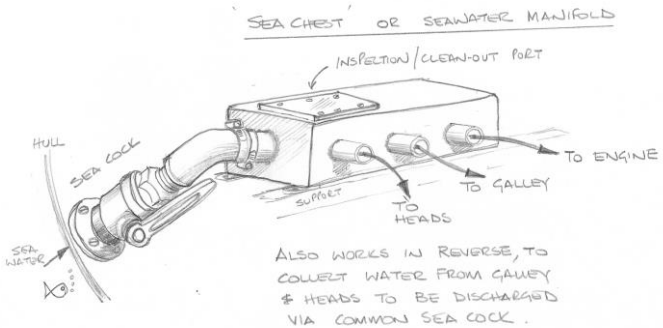
[7,16,17]

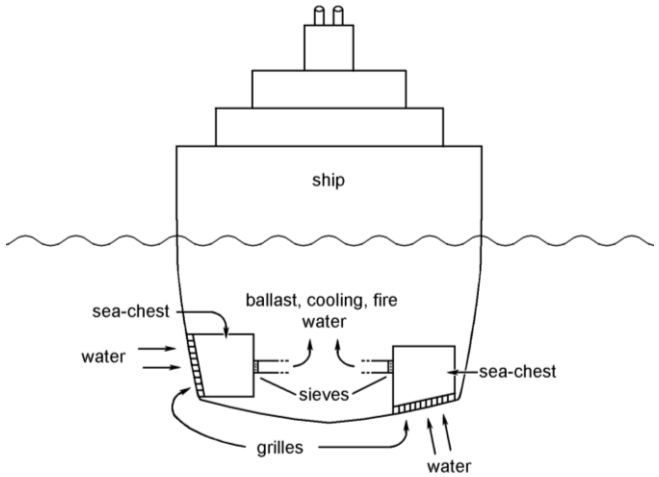
FMEA/FMECA DESCRIPTION - CONTINUED

The primary use of the FMECA is in verifying that single component failures cannot cause catastrophic system failure.

It is best used on well defined systems incorporating mechanical and electrical sub-systems.

It is often best employed in the design stage.





[7,18,19]

FMECA EXAMPLE

An example of an FMECA from the maritime domain (ASEMS).

Filling ballast tanks under gravity							
Ref	System/Equip Failure	Cause	Effect	Detection	Mitigation / Compensation / System Response / Safeguards	Overall assessment	Overall criticality
1BF	Sea Chest	1. Blocked	Tanks do not full. Reduced stability, change of heel/trim increased hull stresses	• Valve position indicators. • Ballast tank level radar/sounding system. • If severe, angle of heel/trim.	i. Clean chest with steam ii. Redundancy 3 other sea chests	In a worst case where failure was not acted upon quickly then a degraded state could arise where the ballasting operation of several tanks could be affected	D
1BF	Sea Chest	2. Loss of sea chest grid integrity	Ingress of foreign bodies possible blockage of control valves and suction piping. Tanks do not fill. Build up of debris in system. Reduced stability, change of heel/trim increased hull stresses.	• Valve position indicators. • Ballast tank level radar/sounding system. • If severe, angle of heel/trim.	i. Clean chest with steam ii. Redundancy 3 other sea chests	In a worst case where failure was not acted upon quickly then a degraded state could arise where the ballasting operation of several tanks could be affected	D
2BF	Sea Chest	1. Partial Blockage	Reduced filling rate.	• Valve position indicator. • Ballast tank level radar/sounding system.	i. Clean chest with steam ii. Redundancy 3 other sea chests	Overall effect considered incipient due to detection ability and redundancy	I
3BF	Sea Chest	1. Leak at sea chest	Loss of ballast control in affected tank. Change of heel/trim.	• Valve position indicator. • Ballast tank level radar/sounding system.	i. Continuously pumped to maintain correct level. ii. Isolate with sea chest blanks. iii. Equalises to exterior sea height in affected tank.	Loss of control in a tank is considered as degraded	D

FMEA/FMECA – PROS AND CONS

Advantages

- Well understood, flexible, easy to interpret, and can be performed by one analyst.
- Is systematic, comprehensive and should identify a large number of hazards.
- Very good at identifying safety critical equipment.
- It provides good system understanding and is also useful in non-safety areas such as reliability.

Disadvantages

- Requires a detailed knowledge of the system before it can begin.
- Does not cover human factors integration, procedures or process equipment well. It also does not cover instances where multiple failures can lead to an accident.
- The biggest drawback however, is the length of time required for a full component level analysis.

ZHA DESCRIPTION

Zonal **H**azard **A**nalysis – ZHA

Zonal Hazard Analysis is used to examine the complex interactions that can occur between systems.

It is specifically concerned with their relative physical positions.

Zonal Hazard Analysis examines the layout of systems to determine whether the actual location of the equipment introduces a Hazard.

It can also determine if a fault in on location can affect the independence of other equipment.

Should start as soon as the physical layout of the system is defined and understood.

Generally utilised in aviation.

[7,25,26]

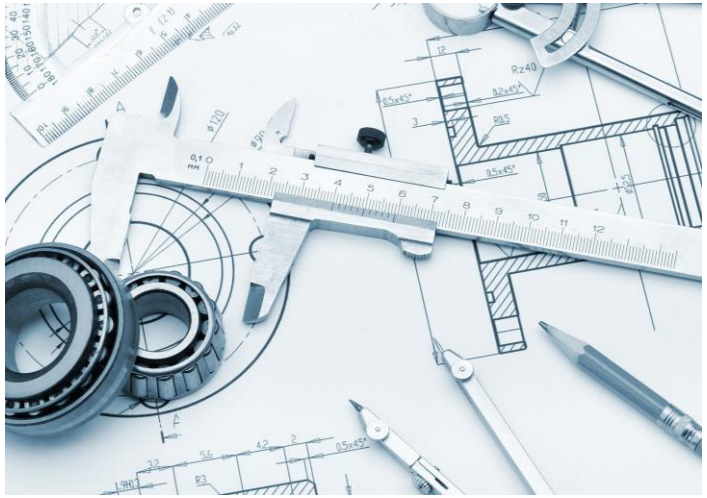
ZHA - PROS AND CONS

Advantages

- The technique considers the installation of the equipment.
- The use of Zonal Hazard Analysis provides the potential to discover how various parts of a system might influence, or might be influenced by their surroundings.
- Maintenance and Procedural errors can be reviewed to establish any potential areas for concern.

Disadvantages

- The results of the analysis may be generated late in the design process.



[7,27,28]

FINAL THOUGHTS

All of these techniques are viable – however some may be better suited to certain situations.

For most projects, multiple techniques will be necessary.

Many of these techniques rely on discussion and ideas, therefore the best way to tell the quality of a Haz ID is the quality of the discussion in the room.

NEXT STEPS...

The final lecture will focus specifically on Hazard and Operability Studies, one particular technique. We will go through this in more detail.

REFERENCES

1. https://www.kpcmhealthandsafetysigns.com/international-hazard-warning-symbol
2. https://www.repubblica.it/economia/2017/04/07/news/la_ue_cambia_i_simbol_sulle_etichette_rischio_discarica_per_molti_prodotti-162336907/
3. Def Stan 00-56: The standard for "Safety Management Requirements for Defence Systems".
4. MOD Safety White Booklet: An Introduction to System Safety Management in the MOD Issue 4 Parts 1 and 2.
5. https://defense-update.com/20170909_6tbattery.html
6. https://www.pinterest.co.uk/pin/406872147570275191/
7. ASEMS Online POSMS - https://www.asems.mod.uk/guidance/posms
8. https://legacyscs.com/warehouse-safety-checklist-8-things-every-manager-review/
9. AOP-15 Ed3 (STANAG 4297) "Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces"
10. https://i2.wp.com/whytoread.com/wp-content/uploads/2014/09/history-books.jpg?fit=1200%2C900&ssl=1
11. https://raw-multimedia.com/2011/08/16/mindful-of-thoughts/
12. https://hushkit.net/2017/06/26/10-amazing-things-you-didnt-know-about-the-supermarine-spitfire/
13. https://www.forces.net/news/all-you-need-know-about-f-35b-lightning-ii
14. https://theamericangenius.com/editorials/theory-versus-reality-of-actual-production-in-the-real-estate-industry/
15. https://seekingalpha.com/article/4064448-comparing-apples-to-oranges
16. https://www.thehulltruth.com/boating-forum/393300-mysterious-sea-chest.html
17. http://www.huffingtonpost.com/cruise-critic/the-best-cruise-ships-for_b_9221120.html
18. http://capnsmarrowblog.blogspot.com/2013/03/nautical-plumbing-pencils-appliance.html
19. https://blog.tepapa.govt.nz/2014/02/13/paddling-among-paddle-crabs/
20. https://www.edutopia.org/discussion/how-brainstorm-so-lightning-will-strike
21. https://www.veryberrycosmo.co.uk/2016/08/lifestyle-what-if.html
22. https://www.inc.com/jessica-stillman/stuck-in-a-mind-numbing-meeting-5-ways-to-be-secre.html
23. https://www.risk.net/derivatives/2466667/banks-take-flexible-approach-pricing-netting-risks
24. https://www.rezway.ca/so-you-missed-the-target-now-what/missed-target/
25. https://www.wccaviation.com/long-take-airline-mechanic/

REFERENCES - CONTINUED

26. https://www.jetartaviation.co.uk/2014/02/tonka-norfolk-land-shark-the-mighty-fin
27. https://outdoors.stackexchange.com/questions/16201/dry-douglas-fir-wood-only-creates-smoke-and-no-fire
28. https://spare-parts-3d.com/2019/02/15/sp3d-business-model/technical-drawings-2/
29. http://little-bitsofjoy.blogspot.com/2012/08/next-steps-towards-kimberlie.html
30. https://en.wikipedia.org/wiki/4.5-inch_Mark_8_naval_gun
31. https://nl.pinterest.com/pin/561964859735352538/
32. https://quotescover.com/kenya-proverb-about-discussion
33. https://www.thinkdefence.co.uk/2022/11/paveway-iv/

THANK YOU FOR LISTENING

ANY QUESTIONS?

SAFETY SERVICES ORGANISATION