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- Order the CDF to reflect their critical dependencies, creating an influence diagram with directed causal links with the feedback paths.
- Classify the Bayesian belief network by defining conditional probability tables capturing consensus beliefs on the probable outcome of key CDF.
- Consider possible interactions and capture their expected influence on the network, as optional CDF.
- Analyze the resultant meshing probabilities to assess the overall hazard level.

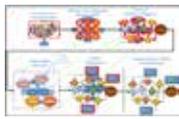


Figure 5. Aviation System Risk Model (ASRM) [22]

An iterative process to develop consensus BBN models of fault propagation incorporating conditional probability estimates for fault propagation and mitigation.

The resultant BASICAL BBN HIRA model demonstrated the ability of a BBN to capture a host of causal risk factors, their interactions and potential mitigations, and their influence on multiple adverse consequences. The full model is too large and complex to be displayed here. The [Table 1](#) shows the primary associated with a single mishap category.



Figure 6. Hazardous Situation Analysis [22]

This diagram depicts the network for a single critical mishap and associated causal links, including event-to-event causal links.

2.5. Phase III: NPS/NVAIR IAS PC Challenge: Interim Flight Crewmember Phase III OQ-REX Demon (OQ-1A, OQ-1B, OQ-1C)

Phase III addressed final IAS applications. The NPS BASICAL IAS flight team, and NPS Inflight rotary wing IAS crewmember assistance. Here we assessed for final mishap category: crash, an collision, non-containment and launch & recovery. Influence network models were completed and consensus for all eight mishap cases, complete with mitigation and conditional probability tables.

In their final meeting, the IAS panel and the project team successfully completed a launch & recovery model including all conditional probability estimates, with consensus from the IAS panel.

A significant advance in the ASRM approach for IAS airworthiness assessment was developed in this phase. In consultation with NVAIR stakeholders, early in the ASRM process the team selected the critical airworthiness mishap categories for the IAS mission, and delineated through a build focused network of causal risk factors and potential mitigations for the more significant mishap categories, e.g. the Fatal crash network in [Table 2](#). This approach greatly reduces model scope and complexity, improving comprehension and confidence in the BBN and the resultant probability estimates.



Figure 7. Crash BBN Model [22]

The BBN approach is consistent with a mishap analysis, with the relevant causal risk network and mitigation shown. The mishap component and critical causal risk factors and mitigations are captured below for a complete presentation of the mishap case. When complete, each node contains the conditional probability for the event to occur within a 10^{-7} to 10^{-9} range.

Additional flexibility was provided by the identification and continuation of two separate sources of BBN software that gave equivalent BBN results:

- the commercial Hugin Expert application; and
- the OpenBay Network Inference (OIN) and Intractual Modeling Inference and Learning Engine (OMILE) BBN software developed by University of Pittsburgh Decision Systems Laboratory, available with a free academic use license.

such as 15000psi, 40000psi and 15000psi results that pressure of angle of in steering engine is scheduled in [Table 2](#) (2) hence, correct understanding of the engine is critical to ensure correct engine of operation. As well as engine of control.



Figure 8. Stall bearing ball bearing of failed steering pump [22]



Figure 9. Stall bearing ball bearing of failed steering pump [22]

Ball bearing has a superior lubricating ball provided from reaction point as shown in [Table 2](#). Ball bearing could not offer resistance to roll over from steering pump as can only pump through gap between ball and cage without restriction.



Figure 10. Stall bearing ball bearing of failed steering pump [22]

Fatal steering pump has been opened into two equal halves as shown in [Table 2](#). Three major observations noted as follows:

- Single lip seal was used as a dual lip seal. Single lip seal used capable to prevent oil at one direction. In the failed steering pump, one has shown that steering oil should flow from inside to outside the steering pump. But that cannot to prevent escape of oily.

Ref: [Table 2](#). Single lip seal has one garter spring on it and lip opens during negative pressure demand near seal. Lip reverts back to original position when no negative pressure exist near seal. That

entry side of seal is projecting towards engine ball face to appearing towards pump. Lip of single lip seal will open if any vacuum exists at pump. Single lip seal is shown in [Table 2](#) on both the side of oil seal. If one lip opens due to valve response pressure of single lip seal, the other lip reverts to original direction and projects oil flow from the other to another place.

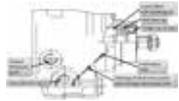


Figure 11. Stall bearing ball bearing of failed steering pump [22]



Figure 12. Stall bearing ball bearing of failed steering pump [22]

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The parameters describing the bubble response include the normalized bubble radius $R_{b,0}$, $R_{b,1}$, and $R_{b,2}$ that correspond to surrounding pressure P_1 , P_2 , and P_3 , and flow orientation with normalized expansion time t . For the Rayleigh-Plesset equation, the bubble radius $R_{b,0}$ is defined as the radius of spherical bubble at a step function shown in [Figure 13](#). The material relation is shown in [Figure 14](#) where the spontaneous optical bubble collapse rate of $R_{b,0}$ was observed to quickly respond to P_1 due to higher external force. The result is that radius $R_{b,0}$ has a longer expansion time with P_1 , which has lower external force and a shorter expansion time.

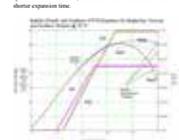


Figure 13. Bubble radius vs time at 70 F [22]

Rayleigh-Plesset equation (RPE) bubble radius at 70 F with viscosity and surface tension is solved numerically as ODE under three external pressures as a step function shown in [Figure 13](#). The material relation is plotted in [Figure 14](#) where spontaneous optical bubble collapse time of $R_{b,0}$ was observed to quickly respond to P_1 due to higher external force. This results in radius $R_{b,2}$ having a longer expansion time with P_2 , which has lower external force and shorter expansion time. The result is much closer to P_2 , $R_{b,1}$ but with slightly lower radius amplitude.

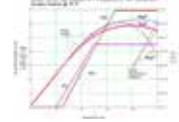


Figure 14. Bubble radius vs time at 250 F [22]

Rayleigh-Plesset equation (RPE) bubble radius at different temperatures 70 F, 250 F, and 500 F with and without the viscosity and surface tension is solved numerically as ODE under a fixed external pressure P_2 as a step function shown in [Figure 15](#). The material relation is plotted in [Figure 16](#) where all radius of spherical bubble have the same expansion collapse time. However, $R_{b,0}$ ($40 \mu\text{m}$) was observed with the largest radius, $R_{b,1}$ ($40 \mu\text{m}$) had the lowest radius, $R_{b,2}$ ($40 \mu\text{m}$) and $R_{b,3}$ ($40 \mu\text{m}$) had almost the same radius as 70 F . This result showed the temperature's impact upon expansion time of bubble collapse radius.

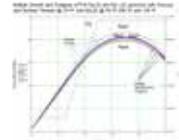


Figure 15. Bubble radius vs time at 70 F [22]

Bubble Kinetic Symptomatology Collapse Energy (KSCE) $\frac{1}{2} \rho \pi R_{b,0}^3 \dot{R}_{b,0}^2$ is a function of bubble radius $R_{b,0}$ and its time derivative $\dot{R}_{b,0}$. It is subsequently proposed that the impact of bubble KSCE upon a nearby surface was the primary energy for causing cavitation damage. The dynamic behavior of the cavitation bubble resulting from the rapidly changing pressure inside the hydraulic machine is related by the radius of the generalized version of the simplified Rayleigh-Plesset equation. The model of the cavitation response potential is based on the conservation of the energy dissipated by the collapse of the cavitation bubble. It is assumed that all the energy emitted during the bubble collapse is used to form the shock wave propagating from the bubble's center. A part of the shock wave energy emitted towards the solid surface is supposed to represent the cavitation potential.

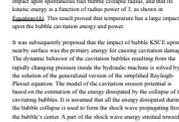


Figure 16. Bubble radius vs time at 250 F [22]

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