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White Paper

Bowties and the Rise of Risk Visualisation

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Introduction

The last couple of decades have seen significant growth in the number of new and highly visual approaches to identifying, assessing, recording and managing risk.

Foundation models like Event and Fault Trees have been around for many years, but as technology and risk management maturity across industries has evolved we are starting to see a tectonic shift towards more tangible and tactile methods for describing risk across organisations and industry sectors. Models such as STAMP & STPA[1], Root Cause Analysis, TOGAF [2] and many, many others are now entering a market place that has traditionally been dominated by the archetypical, venerable but increasingly antiquated Risk Register.

The arguable chief amongst these new visualised risk management approaches (if for no other reason than sheer market penetration and pan-industry popularity) is the Bowtie: a straight forward, logical, barrier-based risk visualisation medium that has found itself on the rapid ascent within both commercial and military aviation in the last five to ten years.

> **"Bowties have become an increasingly common tool for aviation carriers in the support of their obligations towards effective, performance-based safety risk management."**

Since their early introduction to the sector, Bowties have become an increasingly common tool for aviation carriers in the support of their obligations towards effective, performance-based safety risk management. Like every tool however, it's as much about how it is used and the competence of those using it that defines whether or not a Bowtie adds real, tangible value to the management, reduction and monitoring of organisational risk. In this paper we'll explore what can make Bowties a truly ground-breaking aspect of your risk management portfolio and how you can get the most out of them.

[1] Systems-Theoretic Accident Model and Process (STAMP) and Systems-Theoretic Process Analysis (STPA)

[2] The Open Group Architectural Framework (TOGAF)

Why Bowtie?

It's undoubtedly true to say that Bowties have found their mark in the risk management sector and in numerous different industries since their introduction in the late 1980's and early 1990's. Oil and Gas were arguably the first to adopt Bowties at an Industrial scale but since then transportation, health, security, aviation and several other sectors besides have all begun adopting the Bowtie model into their risk management strategies with enthusiasm and excitement. The sheer scale and breadth of industry attendance at this year's CGE Risk Network Event ("Making Risk Understandable" – September 2018) was a testimony to the consistent growth and constant innovation for this comparatively new risk visualisation methodology.

There is, however, always the danger of a concept or technique that appears to be "evolving best practice" being adopted into an organisation's portfolio without a firm grasp of the science behind why or how it came to be so. It's critically important to understand what the benefits of making such a change in risk management approach might be before one embarks on making the change, and to understand how the potential benefits might best be realised. Failure to do so breaks one of the most fundamental principles of effective change management: never make a change simply for change's sake.

So, what are the benefits of adopting a visualised, Bowtie based approach to support your risk management strategy? To answer this, we should first remember that risk management artefacts existed long before Bowties appeared on the landscape, most commonly in the form of the archetypical Risk Register. To explain the benefits Bowties can offer, therefore, it may be simplest to identify some of the challenges and inadequacies that existed before their time and to identify how Bowties have evolved to help resolve them. When looking at the following list of common challenges, ask yourself if any of them apply to your own risk management efforts. If they do, Bowties might be the answer you've been looking for.

Bowties for Show vs Bowties for Pros

Having recognised some or all of these issues within their own walls, most high performing civil and military aviation organisations (and companies in numerous other sectors besides) have elected to adopt a "barrier-based" approach to safety risk management and develop a set of Bowties with which to express, manage and monitor organisational risk. Innovations, techniques and supporting software for Bowties have seen exponential growth in the last decade, and confidence in their use and benefit exploitation is constantly improving.

One of the most appealing aspects of adopting Bowties is the approachability and accessibility of the methodology that underpins them. Learning how to build a basic Bowtie is generally a comparatively straight forward, logical and expeditious affair. Building a truly effective, functional, value adding Bowtie, on the other hand, can be something of a dark art. There is a clear difference between Bowties that add real, tangible value and those that, whilst exquisitely developed, fail to address the fundamental difficulties the organisation faces with the proactive management of risk.

Let me offer an example of one such challenge, common to nearly every risk holding industry, and how a well-constructed, thoughtfully crafted Bowtie can help resolve it.

Challenge	Solution
Risk Admiration vs Risk Management	
Risk Management had become far more an exercise in "risk classification". Review board attention was focused more on the placement of an identified risk on some form of matrix instead of the the reduction of exposure to and severity of that risk through mitigating action. There was little science and significant subjectivity in assessment and evidencing what was deemed "most likely" or "worst credible" risks.	*Bowties are founded on a "barrier based" approach to risk management, where the attention of the reviewer is focused squarely on the organisational efforts to reduce exposure to and mitigate the effects of identified risks. This shift in focus means more active management of risk and less passive admiration of a risk's placement on a matrix. Severity and likelihood of risk can now be demonstrated, evidenced and updated through the performance of mitigating action (barriers).*
Paper Safety and "The Risks of the Register"	
Risk reviews involved a routine "trawl" through a tabular, verbose, text heavy artefact. Detail regarding risk reducing / mitigating action was lacking and, if present, would be predominantly described in highly detailed and technical prose. Up to date information regarding mitigation measure performance would be limited or highly contextual. Risk reviews had become an exercise in paper safety, "probative blindness" and habitual agreement.	*By visualising risk in a logical, approachable and tangible manner the Bowties focus the attention of the reviewing audience on what matters most: the effectiveness and performance of risk mitigating activity. Habitual agreement with mitigation narratives turns to curiosity, discussion and proactive decision making on how to improve "barrier" performance. Management attention is focused on those barriers most in need of attention based on the severity and likelihood of the risks they worked to defeat.*
Seeing is Believing	
The safety risk management strategy (and the artefacts related to it) tended to live in the safety manager's office and rarely received scrutiny from the wider organisation beyond the basic annual requirements of regulated risk reviews. Engagement with staff responsible for delivering the service for an accurate appraisal of the reality of operations was extremely limited. Engagement with the senior management team, especially when describing the need for investment in risk mitigating action, was equally challenging.	*Bowties are a comparatively simple medium for the description and presentation of risk, and well-constructed Bowties have proven themselves to be uniquely accessible to all levels of an organisation: head office to hanger floor. If built and maintained well Bowties can become a predominant source of collaborative risk management understanding that generates positive and proactive mitigating effort across the whole organisation.*

The Risk Communication Conundrum

Arguably the most important indicator of truly functional Bowties is their ability to vastly improve the identification, communication, description and ownership of **risk across the whole workforce**: from head office to the hanger floor. This last part is crucial and is something so many budding Bowties miss in their mistaken pursuit of intricate detail, reduced administrative burdens or numerous other secondary considerations.

One of Bowties greatest potential benefits is their ability to better inform those with accountabilities and responsibilities for risk in more coherent and focused ways than has otherwise been possible. Bowties visualise, in an approachable and accessible way, the layers of mitigation that stand between the sustainable continuation of day to day operations and the detrimental events that could cause them harm. As they do, they can also highlight where the weaknesses lay, what the weaknesses stem from, how serious these weaknesses are in relation to the potential disasters they hope to prevent and how they might be resolved. They can guide corrective action to the places it is most needed and help develop the action plan of what must be done, by whom and how urgently. The value such a pictorial exposition can make to the targeted, efficient and effective allocation of organisational resources in the pursuit of reduced risk exposure cannot be overstated.

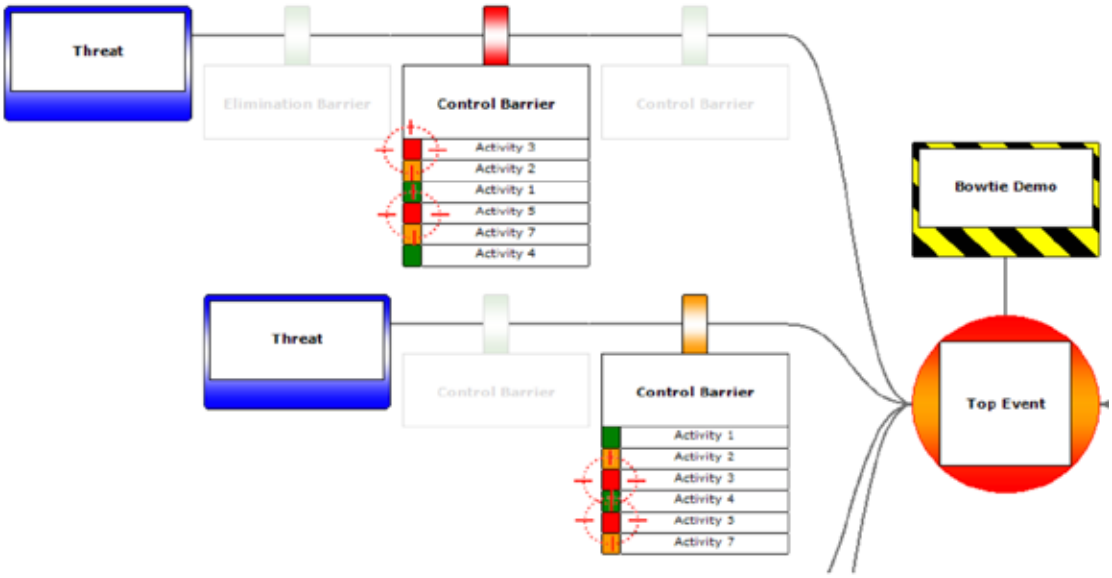
Barrier management & performance oversight at the "strategic" accountable management level

In order to realise this benefit, however, the barrier strategy the Bowties describe needs to be accurate, up to date and honestly reflective of the day to day working situation. The operational hazards faced day to day need to be fully identified. Harmful consequences need to be credibly scoped and clearly described. Risk mitigations (and their relevant working parts) need to be represented with all the necessary detail to accurately assess their operational effectiveness.

The best and most reliable source of all this vital information will inevitably be the "front line" workforce who live and breathe the real-world operational environment: the subject matter experts who intimately understand the day to day reality and are most intimately involved in making risk reducing barriers, mitigations and processes work. Here in lies both the problem and the solution that a well-crafted Bowtie can offer.

Executive boards, senior directorship, accountable persons all operate at the strategic level of organisational governance. At this macro level it's often difficult to see how a couple of missing tools on the shadow board, a minor procedural short cut or a smattering of drone sightings on the approach can credibly relate to the catastrophic failure of operating safety and how that might ultimately bring the organisation to its knees.

Those staff delivering the service, meanwhile, talk the language of day to day operational occurrences, hazard observations, delivery pressures and functional difficulties in the pursuit of operational delivery, profit generation and client satisfaction. They see and live with many of the operational hazards, they work through the challenges and they're often the ones who most intimately feel the harm when things go wrong. They often also struggle to communicate these real-world conditions to the accountable hierarchy in a language they fully understand. Their intimate familiarity with the specific details of barrier performance is both their greatest contribution to the strategic risk picture and their greatest blocker to communication with those holding the levers to fix them.



Detailed barrier performance assessment and report integration at the "tactical" workforce level

These two distinct audiences, symbiotically interdependent though they are, often find themselves chronically disconnected through their differing perspectives, language and perceptions of organisational risk. The results of this disconnection?

1. A poorly informed accountable management team unknowingly tolerating levels of risk exposure that may, in reality, be patently intolerable.

2. A workforce frustrated by the apparent inaction their attempts at communication are met with, working in an environment that is potentially exposed to significant degrees of risk.

3. A safety culture fundamentally undermined by the organisation's inability to communicate, collaborate and cooperate in the management of risk for mutual benefit.

"How terrible is wisdom, when it brings no profit to the wise"

Sophocles, Oedipus Rex

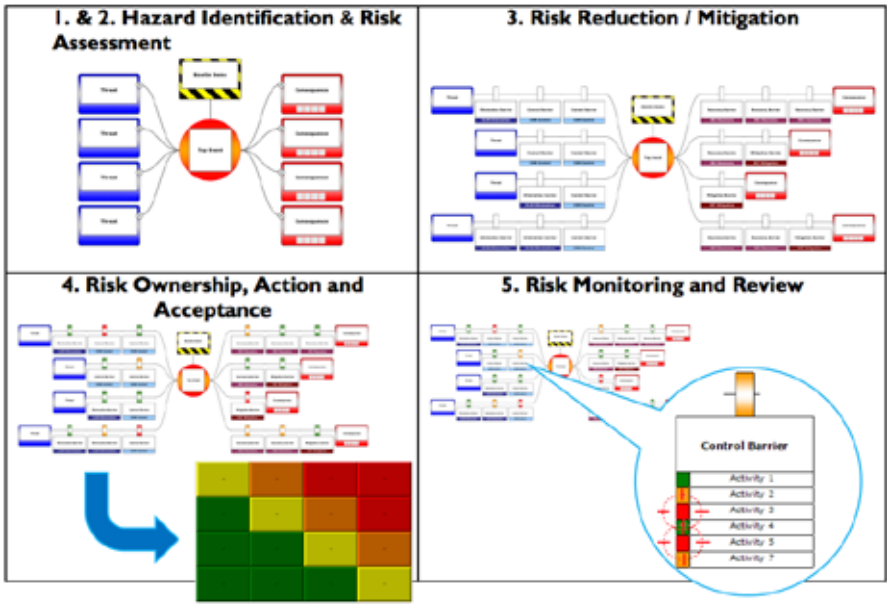
A well-made Bowtie therefore is one that brings these two critical stakeholders together in a single, universally agreed presentation of risk. It is one that speaks both their languages and answers both side's questions at the same time and in the same diagram. The well-built Bowtie will be able to focus management attention on the tactical problems that have detrimental strategic implications, enabling the right changes to be made in the right places, satisfying the workforce that their voices are being heard and improving overall safety performance as they do so.

The old saying goes that a picture paints a thousand words: I would only add that the best pictures can also speak a thousand languages. Proof of a well-built Bowtie lays not in how much detail can be shoe horned into it, how much information can be made to fit on a single page or how many different colours it uses. Truly professional, demonstrably effective Bowties are defined by how well and how often the organisation's stakeholders engage with them and what proactive improvements in risk management and safety performance they inspire.

A Bowtie for All Seasons

It's worth point out at this stage that Bowties are founded on ISO 31000 principles and, as such, are entirely aligned with the essential basic steps of risk management. Depending on the specific sector or regulatory environment these steps may be described in numerous different ways, but they all essentially fall into a "golden five" process of **Hazard Identification, Risk Assessment, Risk Reduction / Mitigation, Risk Ownership, Action and Acceptance and Risk Monitoring and Review.**

Given the Bowtie methodology's intrinsic connection to the fundamentals of risk management, it is possible to support those requirements for Safety Risk Management within EASA's regulatory framework through the development, integration and maintenance of Bowties within an organisation's Safety Management System.



Bowtie development aligned with the essential steps of the Risk Management "5 Step Cycle"

Note that simply having Bowties is not nearly enough to satisfy the specific requirements of EASA ORO Gen 200, ICAO 9859 or the UK MAA's RA1210. The Bowties need to be fully embedded into the occurrence management, risk sanctioning and safety governance processes of the organisation to satisfy the spirit and intent of the requirements for effective safety risk management within aviation organisations.

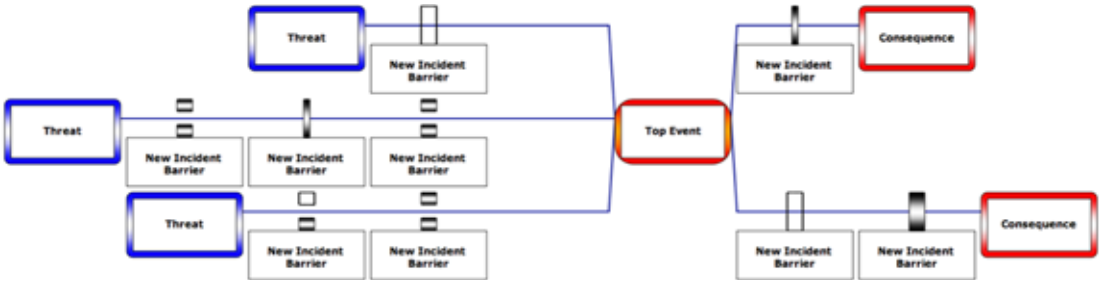
Some innovators in the field have realised significant time and effort efficiencies by exchanging multiple disparate RM processes for a single, cohesive system using Bowties as the underpinning structure for risk identification, assessment, management and monitoring. Their efforts have become more streamlined, more holistic, more connected and ultimately more effective whilst at the same time becoming easier to manage and simpler to maintain through a common approach using a single artefact. And, as we all know, the simpler things are to manage the more likely they are to be managed well.

A few high performing organisations have taken this efficiency potential a step further, integrating compliance management and compliance monitoring into the foundations of Bowtie development wherever and whenever possible. This allows for compliance to be tracked, actioned and demonstrated whilst also showing the effect compliance has on the effective management of safety risk: a powerful tool as aviation moves further and further down the road of performance based regulatory oversight. We've seen this shift organisational thinking away from an old school attitude of "compliance for compliance's sake" into a more enlightened position of "compliance for organisational resilience and the consistent delivery of risk reduction effect".

It's also important to understand that Bowties can serve numerous different functions in an organisation or an industry: not all are made with the same intentions in mind. Baines Simmons' sister organisation Clockwork Research, who specialise in fatigue identification and fatigue risk management, have developed a bespoke "Fatigue" Bowtie that explores in detail the numerous distinct ways in which fatigue can occur and the multifarious ways its impact may be felt if it does.

This bespoke artefact is more what some would described as a "Work Bowtie", designed to describe specific hazardous conditions and educate the workforce on specific causal factors, potential consequences and critical barriers to their prevention. Clockwork's "fatigue" Bowtie can support the development of specific fatigue management controls (that would then be integrated into the "traditional" risk management Bowties) whilst also enabling a degree of pan-industry trending and collaborative sharing of fatigue management best practices.

It is also entirely possible to reverse engineer an occurrence, incident or accident using a Bowtie model to help visualise the sequence of events and the barriers that were supposed to prevent them (but failed to do so). This has been used to good effect by investigators, auditors and safety staff to explain, in simple visual terms, how an event happened, but it can also be used to visualise how events *might* happen in the future given current barrier performance.



Both these "styles" of Bowtie are quite explicit and narrow in function. They might be too detailed and specific for the strategic management of safety risk across a whole organisation but they can become powerful risk communication tools in their own right and/or use their tactical perspective to inform the "strategic" Bowties on barrier performance at the operational level.

Regulators have also been making increasing use of Bowties as communication and education tools in recent years. Using the taxonomy of their "Significant 7" safety priorities as a starting point, and in broad consultation with Industry subject experts, the UK CAA have developed a set of "high risk scenario" Bowties that identify pan-industry mitigations for commonly experienced threats as well as potential degrading factors the regulator wishes to highlight to the regulated community for specific consideration and proactive management.

The Future of Bowties in Aviation

The aviation industry has been fortunate to often find itself out front when it comes to innovation and continuous improvement in the wider field of Safety Management. Cutting edge approaches like Bowties have therefore found fertile ground within the culture, maturity and approach of the aviation industry to prove their worth as tangible improvements on the artefacts of the past.

At the latest CARM Working Group[3], for example, Bowties were recognised and demonstrated as a natural and highly complementary partner to the already established ARMS[4] ERC risk management

[3] Common Aviation Risk Models (CARM) Working Group, led by The Aloft Group and hosted by CGE Risk (1st Oct 18)

[4] Aviation Risk Management Solutions

toolset through their shared application of "barrier based" thinking. Where ARMS asks organisations to project risk likelihood[5] and event severity[6] through assessment of the effectiveness and performance of barriers (as opposed to the more fragile and subjective analysis methods of the past), the Bowties enable a structured and objective assessment of the whole barrier system on which to base a judgement. By combining the two tools, the employment of the ARMS toolset is made exponentially more objective and robust whilst the Bowties are elevated from visual models to living, breathing risk management artefacts through integration with day to day safety management activity.

The UK's Defence Aviation Environment (DAE) has also seen a marked growth in competence and confidence with the use of Bowties as the foundation of risk-based safety arguments in the last few years. The UK Military Aviation Authority is increasingly investing in aligning the reporting and occurrence management processes of their Error Management System with the Bowties that accountable risk holders (Duty Holders in military parlance) employ to monitor, manage and maintain their respective risk portfolios to an ALARP (As Low as Reasonably Practicable) and Tolerable level.

Well-constructed Bowties also offer opportunities to help an organisation measure its safety management system's effectiveness in more quantifiable terms through the regular review, auditing and oversight of barrier performance. Barriers that are intelligently linked to SMS key performance indicators can answer many questions "in one sitting", directly feeding the assessment of risk likelihood and severity whilst also providing useful strategic insight into wider safety management challenges and improvement opportunities.

And then there's the true nirvana: the accurate and reliable projection of risk likelihood and severity based on quantified barrier performance and proactive barrier failure analysis. CGE's BowtieXP already includes a Levels of Protection Analysis (LOPA) "plug in" that allows organisations in specific industries to apply "safety targets" to consequences and use collective barrier performance to calculate their achievement (or otherwise). Other projective capabilities (such as LONE STAR, the flagship product for a Dallas based enterprise analytics company by the same name) are also evolving along these lines using such cutting-edge concepts as "calibrated questions" and detailed barrier relationship modelling to improve the rigour and reliability of projected risk assessments. These tools look particularly interesting when assessing the impact of future change on organisational safety performance and risk exposure: something aviation wrestles with by regulatory mandate.

In short, the future looks incredibly bright for Bowties across a broad and growing spectrum of industries and sectors. Their barrier-centric approach to risk management is now so firmly embedded in aviation's consciousness that it can sometimes be hard to remember how on earth we did things differently before. Whilst their expansion and growing exploitation is symptomatic of aviation's drive for continuous improvement it's always worth taking a moment to remember where we were before their arrival, if for no other reason than to appreciate why and how they have made things better.

Bowtie screenshots provided using BowtieXP by CGE Risk Management Solutions

[5] Through the Safety Issue Risk Assessment (SIRA) tool

[6] Using Event Risk Classification (ERC)

About the Author

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Mark is a highly skilled and dynamic safety management consultant with specialties in risk assessment, safety performance, error management and SMS improvement as well as a pedigree in the emerging market of civil and military unmanned aviation. His consulting skills, advice and innovations for military SMS are widely recognised across the Defence air safety community as leading in best practice for air asset risk assessment and risk articulation, particularly in the successful employment of the Bowtie methodology.

About Baines Simmons

We are specialists in aviation regulations, compliance and safety management and partner with the world's leading civil and defence aviation organisations to improve safety performance.

As trusted advisors to businesses, armed forces, governments and regulators across all sectors of aviation, we help to advance best practice, shape safety thinking and drive continuous improvement to safety performance through our consulting, training and outsourced services.