定性的空域安全性評価手法について

航空交通管理領域
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内容

1. 安全管理システム
2. 危険因子同定・安全評価・安全監視手法
3. 電子航法研究所の試み (WebHiRAS)

「安全」の定義

安全とはハザード同定とリスク管理の継続的な過程を通じて実現される人／財産に対するリスクが受容可能なレベル以下に維持／低減されている状態である。

ハザード（危険因子）・・・

人・物に対する損害や逸失・所定の業務／機能を実施する能力の低減を引き起こしうる可能性のある状況やもの

リスク = ハザード（危険源） + 頻度 + 結果の重大さ

受容可能レベル・・・リスクが「ゼロ」ということを意味しない。

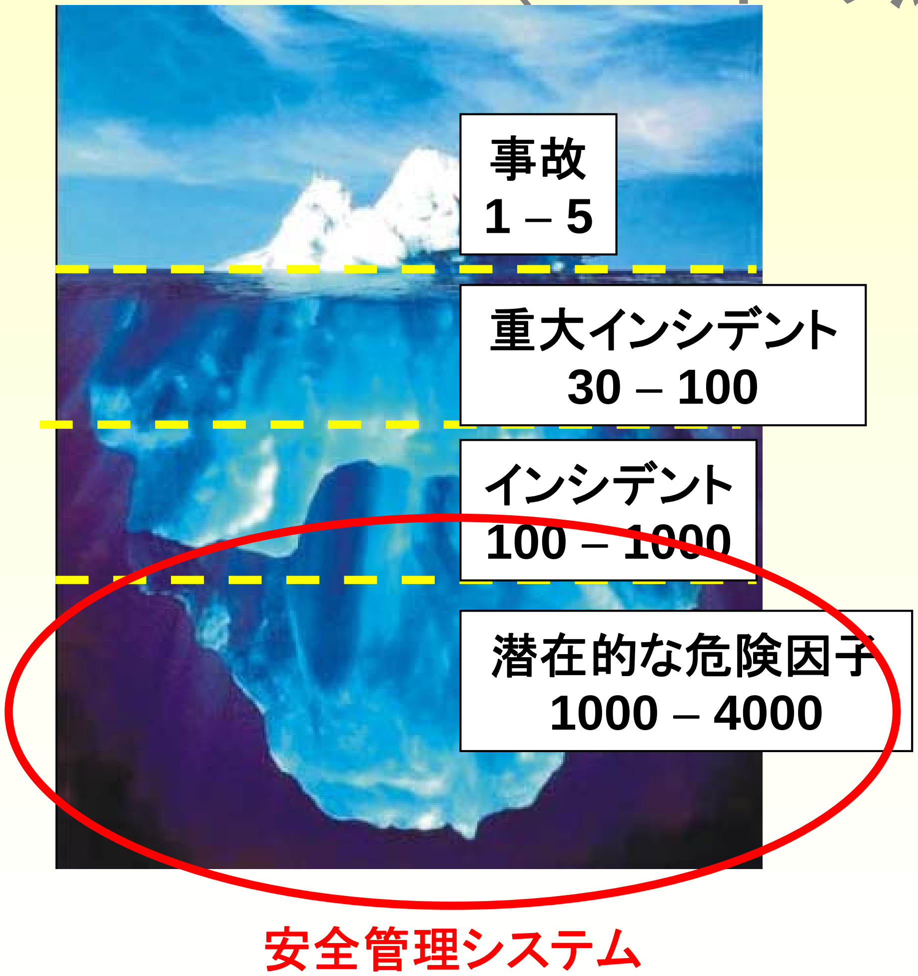
受容可能性は「社会的コンセンサス」が必要

ハザード同定とリスク管理・・・安全管理システム（SMS）の主要な活動

安全管理システム

- ICAO推奨の安全を系統的に管理する手法。
  - 導入が義務付けられている分野
    - 認定訓練組織，航空機の運航者，整備事業場，ヘリの整備，航空機の設計製造，航空交通業務，飛行場業務
  - 類似分野
    - 品質保証
  - 目的
    - 潜在的な危険因子の発見･対策

ハインリッヒの法則
（バートの法則）

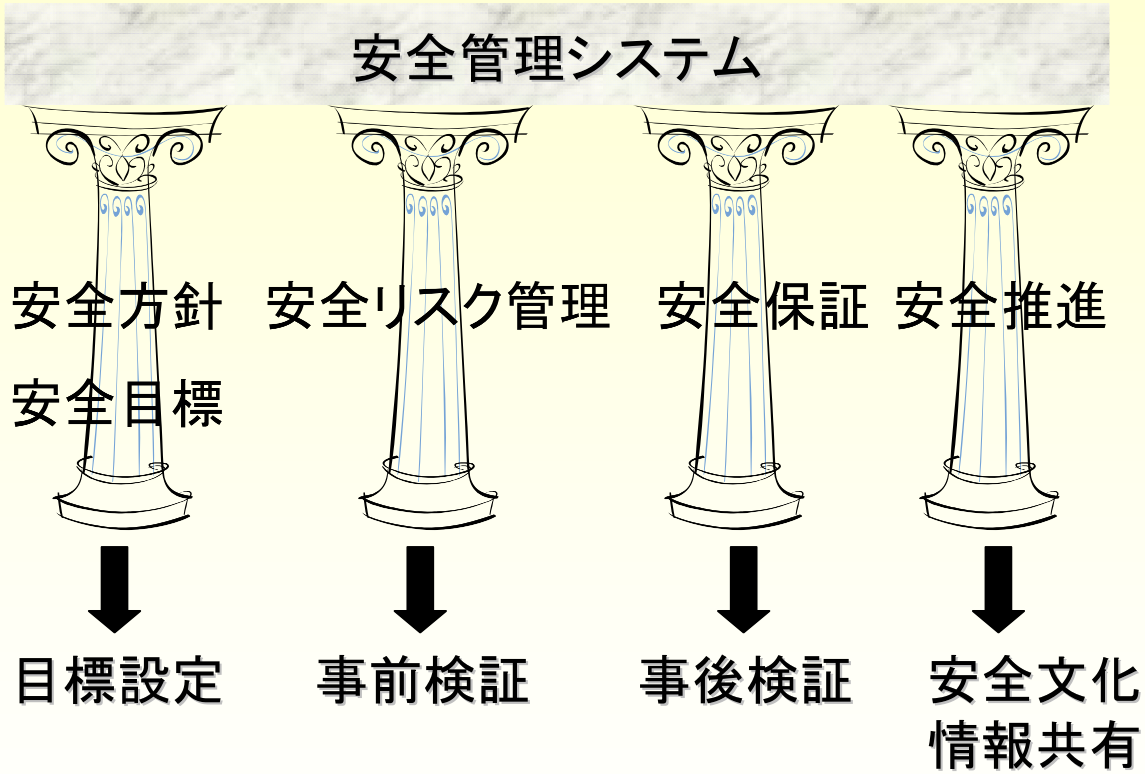


一つの事故の背景にはたくさんの重大インシデントがあり、その背景にはさらに多くの危険因子があり、その背後にはさらに多くのヒヤリハットがある。

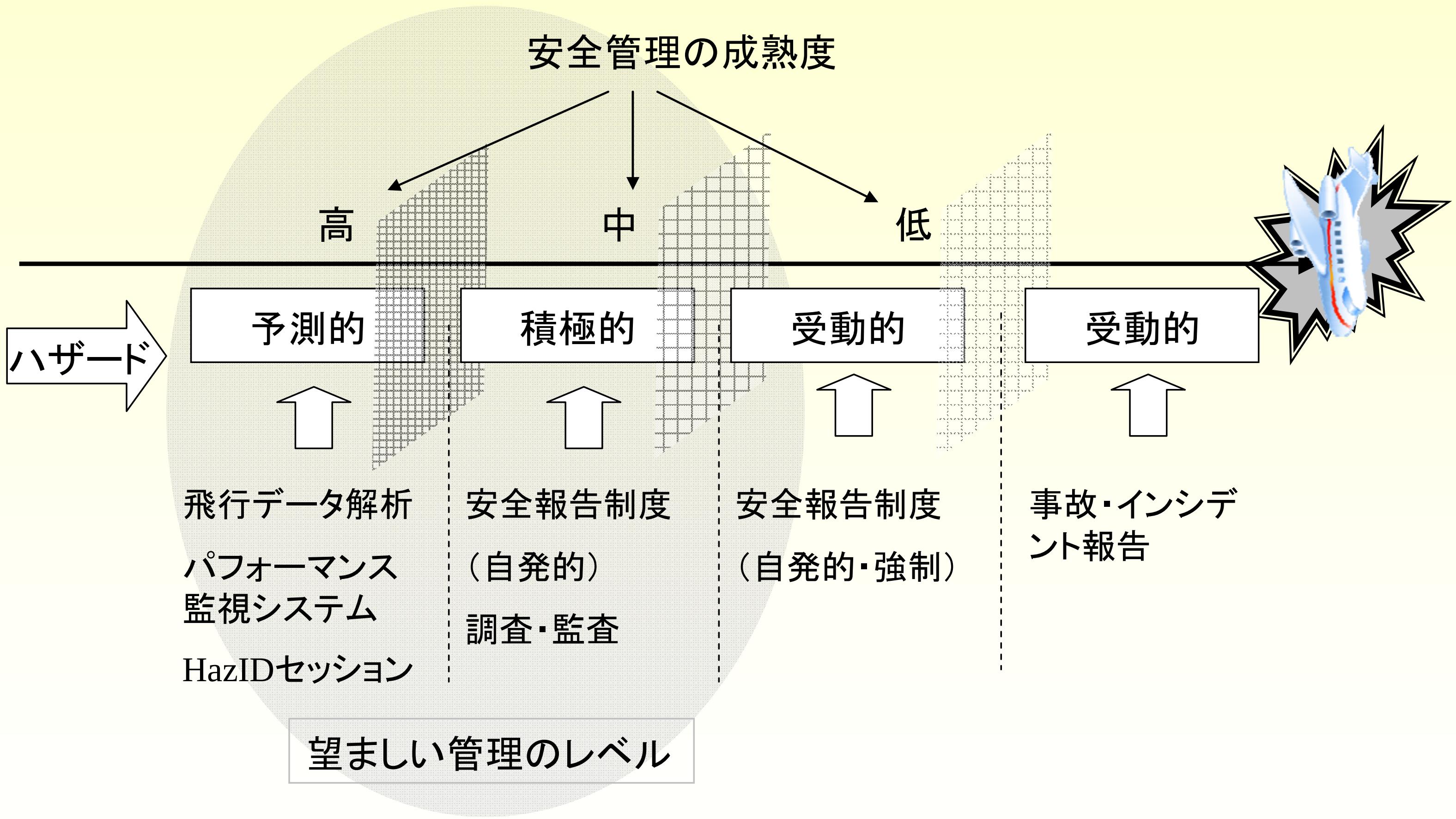
↓

潜在的危険因子の段階で、危険の芽を摘み、事故を防止。

安全管理システム
4本の柱



安全管理システム
成熟度



ハザード同定・安全評価・安全監視手法

安全情報データの蓄積

- 安全報告制度・安全情報データベース
  - 「ヒヤリハット情報」を収集・蓄積し、それを活用する枠組み
  - 例：航空安全報告制度(NASA)
  - 安全報告制度が機能する条件→匿名・非懲罰

CALLBACK

From NASA's Aviation Safety Reporting System

ASRS

Number 364 April 2010

Safe Operations at Non-Towered Airports

The key to communicating at an airport without an operating Control Tower is selection of the correct common frequency for airport advisories while operating to or from the airport. CTAF, which stands for Common Traffic Advisory Frequency, is designated for this purpose. Use of the correct CTAF, combined with visual alertness and application of recommended operating practices, will enhance safety of flight during non-Towered operations.

This month we focus on ASRS non-Towered airport incidents that emphasize the following themes:

- **Communication** – Monitoring CTAF and use of the radio to report position and intentions.
- **Traffic Mix** – Being aware that straight-in IFR traffic to a non-Towered field may conflict with patterns for VFR traffic, especially in reduced visibility conditions (broken or overcast ceilings, haze, etc.).
- **Avoidance** – Practicing see-and-avoid procedures and visually checking the final approach course before takeoff or landing.
- **Frequency** – Use of the correct CTAF and current charts and flight information.

Monitor CTAF and Use Radios

An ATP-rated passenger in a Mooney aircraft was "along for the ride" when the owner/pilot neglected to follow recommended communication procedures at a non-Towered airport.

■ *The owner/pilot in command was flying and I was a passenger/observer. He entered the traffic pattern at approximately 800 feet AGL mid-field. Pilot did not monitor CTAF – he entered base and final and landed without incident. A C-210 was on opposite direction final at the time and he had to initiate a go-around to avoid conflict on landing. C-210 pilot was very upset on the ground after landing. Mooney pilot departed before a confrontation occurred. There were no injuries or damage, but this event could have been avoided....*

In another incident, a GA pilot flying a low approach to a non-Towered field had a near mid-air collision with a non-communicating C-172 departing from an intersecting runway.

■ *When flying my Mooney M20-F into* [the] *field, I decided to fly a low approach on Runway 4/22 to get a feel for the winds that were steady at 20 knots. I radioed my first position 3 miles out from the field and requested traffic information. There was no response. I set up for a 45 to midfield downwind left traffic pattern for 4/22 and made at least 2 more radio calls on the CTAF frequency 123.0 stating my position and intentions to fly a low approach on 4/22.*

While executing the low approach, a Cessna 172 passed over the top of my airplane at the intersection of Runway 4/22 and 31/13. He had taken off from Runway 31 without making radio calls, listening to radio calls, or checking for traffic.

Be Aware of IFR/VFR Traffic

A non-Towered airport may be an airport without a Control Tower, or an airport where the Control Tower operates part-time. At either type of airport, IFR aircraft may be making straight-in or other types of approaches, while VFR aircraft are flying standard traffic patterns to the active runway(s). This situation is especially likely to create conflicts in low visibility conditions.

Here is one such example, in which a corporate IFR aircraft was cleared for an RNAV (GPS) approach in IMC conditions, and experienced a near-mid-air collision with issued VFR traffic. Reported altitude of the encounter was 2,200 feet MSL.

■ *I had been issued approach clearance for the RNAV approach to Runway 19 at* [a] *regional airport. After crossing the initial approach fix....the Controller issued a traffic advisory for a VFR aircraft just to the north of the intermediate fix. I saw him on TCAD* [Traffic and Collision Alert Device] *and switched over to the CTAF frequency and advised him or her that I was on the approach and heading toward him. I received no reply, but the aircraft started turning toward me and climbing. I had told the Controller I would make a 360-degree turn to the right to give the other aircraft time to do something. He did it wrong, he turned toward me after I told him where I was. He may not have been on that frequency when I saw him turning toward me. I dove my aircraft sufficiently to have the TCAD start yelling sink rate. He passed directly overhead at somewhere between 50 to 100 feet above me. At that time I broke out of the clouds and visually recovered. I went around, climbed back to altitude, and rejoined the approach.*

I never saw the other aircraft visually. I told the Controller that I had been solid IMC throughout the entire avoidance until I broke out. The Controller was very helpful throughout.

In another example of IFR/VFR traffic mix, an air carrier on an ILS approach to a non-Towered field experienced a conflict with a VFR aircraft practicing the same approach.

■ *While descending we were cleared for the ILS for Runway 7 and ATC told us that there was VFR traffic to our north and that it was unverified. We told ATC we were looking for traffic. ATC then advised us that frequency change was approved so we could monitor CTAF frequency since this is an uncontrolled field. We had been cleared direct to the FAF and cleared for the ILS 7. We made our initial calls on CTAF trying to reach the VFR traffic. They were initially north of the approach and I thought they were doing maneuvers. We then heard the traffic state they were turning inbound on the procedure turn for the ILS 7. I guess they were practicing approaches while VFR. This is the time we noticed that they were turning inbound right towards us. We were now just over the FAF and the traffic was on a dangerous course towards our aircraft. To prevent a collision, the Captain turned to the south to avoid the VFR traffic and said we will have to make a 180-degree turn...so we would remain clear of the VFR traffic...The rest of the approach was uneventful....*

ASRS Alerts Issued in February 2010

Subject of Alert	No. of Alerts
Aircraft or aircraft equipment	9
Airport facility or procedure	13
ATC equipment or procedures	5
Maintenance procedure	3
TOTAL	30

A Monthly Safety Bulletin from

The Office of the NASA Aviation Safety Reporting System, P.O. Box 189, Moffett Field, CA 94035-0189

http://asrs.arc.nasa.gov/

February 2010 Report Intake

Air Carrier/Air Taxi Pilots	2673
General Aviation Pilots	751
Controllers	535
Cabin/Mechanics/Military/Other	393
TOTAL	4352

http://asrs.arc.nasa.gov/

構造化ミーティング
（事前検証）

- 潜在的な危険因子の同定・リスク評価手法の一つ
- 当該手法の専門家が議長となり，ミーティングを通して，評価対象となる方式やシステムの専門家から考えうる危険因子を引き出す．
- 専門家の経験に基づき，危険因子の発生頻度と危険因子発生時の被害の度合いを見積もることもある．

STCAへの適用事例

Hazard Ref:	Hazard Title	Hazard Description	Hazard Effect on ATM	Severity & Exposure Time (Ref SAM Severity Classification Scheme)	Mitigation Means
OS 1 – Flight in Formation/Trail					
H-[OS 1]-1	Partial Transponder failure (lost mode A)	Partial transponder failure (lost mode A) potentially leading to missed genuine alerts, when in conflict with no mode C and unassumed tracks	ATM safety not enhanced by STCA The Controller may become aware too late of a potential conflict to resolve it before a collision scenario develops. There may be a proportionate increase in the number of conflicts recovered by the pilot or providence to non STCA levels	Severity 3 Resolution and/or recovery functions partially impaired. Possible significant increase in workload or stress, particularly at peak traffic times.	Procedure for "manual correlation" to allow the track to be assumed again and STCA being fully active for the track (note that manual correlation is already normal ATCO practice at Semmerzake ATCC)

危険因子同定実施例

COSPACE HAZOP REPORT (combined controller and pilot)

Appendix B. Scenarios developed for CoSpace HAZOP

Figure B1. Matrix of the 4 scenarios developed

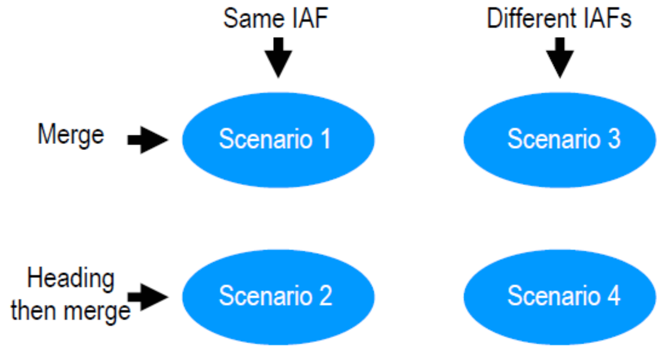


Figure B2. Airspace used for the HAZOP

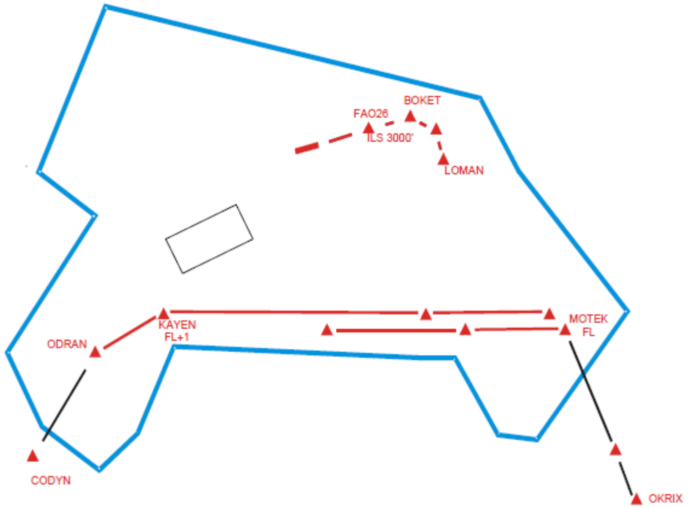


Table B1. CoSpace HAZOP Scenario 4

A pair of aircraft (A and B), from different IAFs, A and B using sequencing leg; If B under spacing do step 2 (spacing cancellation and speed). Grey writing indicates this task step has been covered in scenario 1.

	Task Step	Controller	PNF	PF
1	First call B	Identification		Announce
2	→Spacing cancellation and speed for B	1. Instruction		
			2. Read-back	
			3. Cancel spacing and deselect target (MCDU)	4. Execute speed (FCU)
			5. Crosscheck of speed action (PFD)	
3	→Target selection for B	1. Instruction	2. Read-back	
			3. Input code (MCDU)	4. Visualisation and positioning to PNF (ND)
			5. Crosscheck of positioning (ND)	
4	→Target identification for B	2. Target confirmation	1. Target positioning to ATC	3. Target validation (MCDU)
5	→Continue heading	1. Instruction		
			2. Read-back	
			3. Input instruction, WPT and spacing value (MCDU)	3bis. Maintain current heading
				4. Check feasibility (MCDU)
			5. Instruction validation (MCDU)	
				6. Monitor the acquisition of spacing (ND)
				7. Initiate direct to WPT

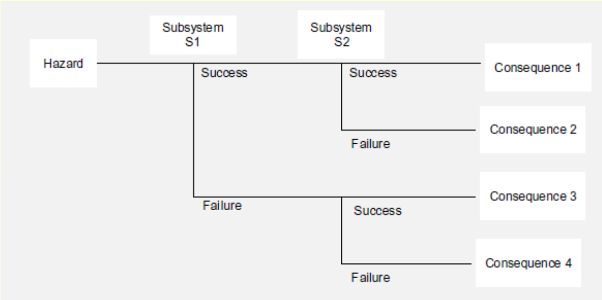
危険因子同定実施例
（ログの例）

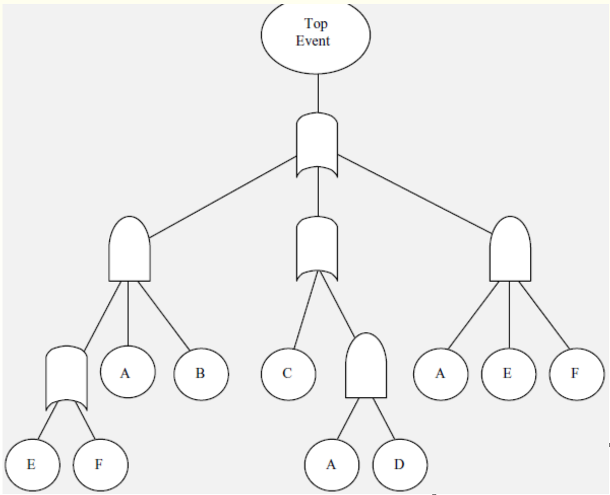
(Numbers in brackets refer to the original numbering system; grey boxes refer to error/failure modes not discussed during the consolidation HAZOP – severity level 4)

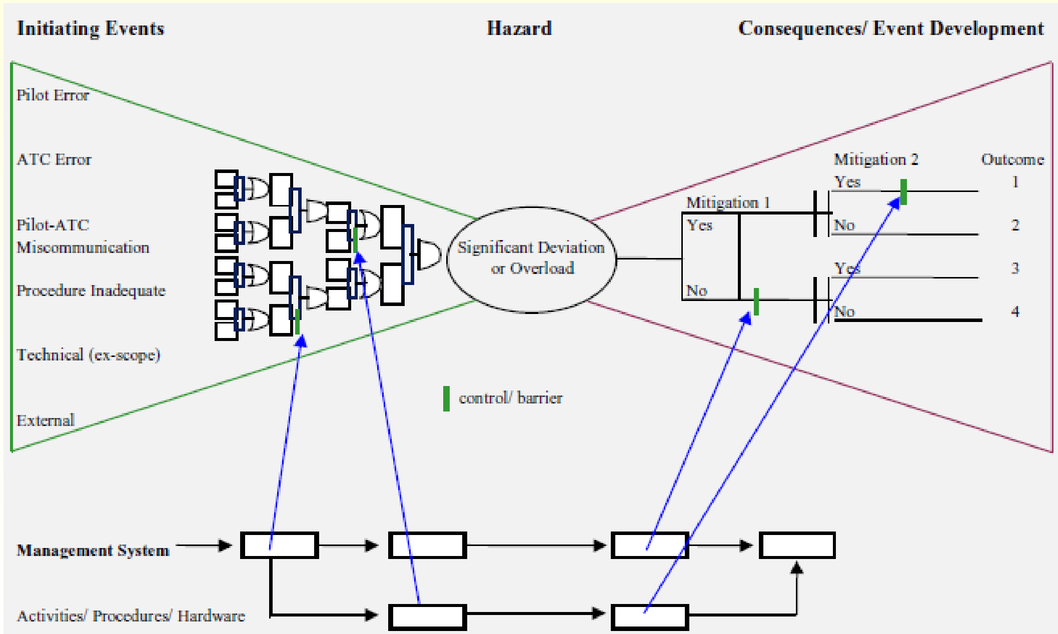
Error #	TASK	GUIDEWORD DEVIATION /ERROR	CAUSES	CONSEQUENCES	RISK RANKING	RECOVERY / SAFEGUARDS	RECOMMENDATIONS
A. SEQUENCE ORDER NOT IDENTIFIED OR IDENTIFIED TOO LATE							
A.1 ATC	1. 1 Sequence order identification (EXC)	No sequence order identification (none)	- High traffic - Adverse weather (Cb)	- No ASAS - More workload	Sev – 4 Freq - 4	- Open another freq – 2 executive ATCOs (pick-up & feeder) - Quick sector change - Open holding stacks	- Training – transition from working with to without ASAS - Training - High traffic/ without ASAS
A.2 ATC	1.1 Sequence order identification (EXC)	Non-ASAS-equipped a/c in sequence (other than)	- Non-ASAS a/c not identified (HMI, strips) - Not seen by PC	- Confusion (non-ASAS equipped a/c can be a target a/c) and ATCo may assign them as an Instructed a/c - Workload	Sev – 4 Freq – 4/5	- Non-ASAS pilot will ask ATCO for clarification	- Check this issue with pilots - Ensure HMI is clear with respect to ASAS and non-ASAS equipage; including non-serviceable ASAS equipage - Tool to better identify sequence (e.g. like AMAN) - Teamworking training – between PLC and EXE
A.3 ATC	1.1 Sequence order identification (EXC)	Planning started too far in advance (sooner than)	- Flow management error (higher volume of traffic) - Over-trust in AMAN	- Forget other traffic coming into the sector at the last moment - Wrong sequence - Workload for EXE	Sev – 4 Freq - 4	- EXE	- More stable AMAN - AMAN calibration training for EXE, PLC, SEQ (understanding the limits of AMAN)
A.4 ATC	1.1 Sequence order identification (EXC)	Sequence order identified late (later than)	- Overloaded PLC	- Overloaded EXE	Sev – 4 Freq – 4/5	- Open holding stacks	- Training for PLC - PLC will no longer do the co-ordination tasks for a short period (role consolidation) task shedding/ additional role - Team Resource Management (including E-TMA controllers) to

頻度・被害の深刻度の分析（事前検証）

- Human In The Loop (HITL)シミュレーション
- 事象木，故障木，蝶ネクタイ





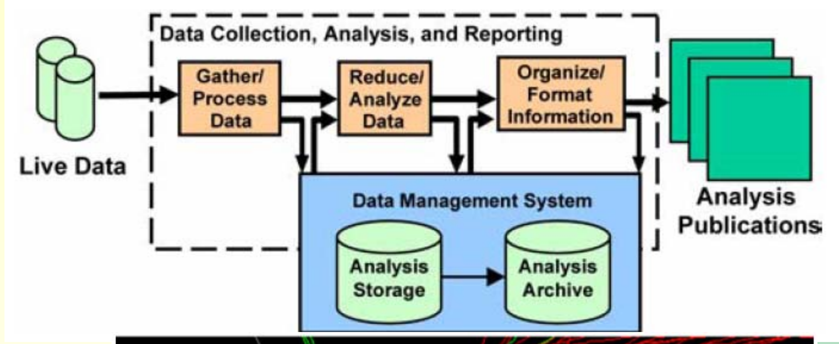


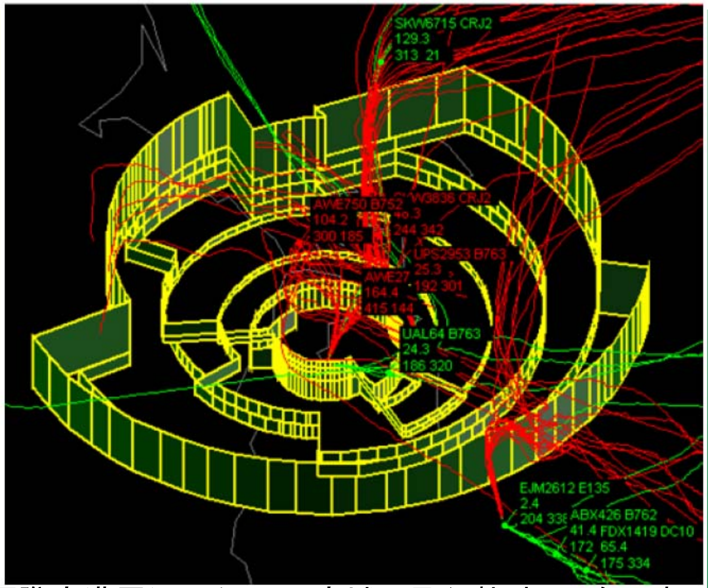
安全保証

- 運用中も変わらず安全であることを保証し続ける。
  1. 安全リスク管理フェーズで見逃した危険因子の同定→安全報告制度・安全情報データベース
  2. 安全リスク管理における解析で仮定された仮定の継続的な妥当性検証→継続的監視
  3. 特定された危険因子の発生頻度の確認→継続的監視

PDARS
(Performance Data Analysis & Reporting System)

- FAAとNASAが共同開発
- 主な機能
  - 航跡データと飛行計画の自動収集と分析
  - 日報の自動生成
  - GRADEによる可視化
  - データと報告書の配布





GRADEによるサンフランシスコ国際空港周辺のクラスB空域の飛行軌跡の3次元表示

Regional Monitoring Agency (RMA)

- RMAはRVSM導入前そして導入後、継続的に以下の項目を監視し、監視の結果、RVSM運用要件が満たされていないことが判明すれば、対応策を開始する国際機関
  - RVSM承認機以外がRVSM空域を飛行していないか？
  - RVSM承認機の高度維持性能は要件を満たしているか？
  - RVSM運航に起因する空域の衝突危険度が許容範囲内にあるか？

WebHiRAS (1)
（電子航法研究所の試み）

- 構造化ミーティング
  - 短所
    - 参加者のスケジュール調整の困難さ
    - 遠隔地からの参加コスト
    - 限られたミーティング時間
    - 記録の手間
- Web技術
  - 双方向コミュニケーションツールとして発展

WebHiRAS (2)
（電子航法研究所の試み）

- WebHiRAS （鋭意開発中）
  ネット上で実施される構造化ミーティング

役割	担当者	
	構造化ミーティング	WebHiRAS
テクニカルサポート		Web技術者
事務局	司会・書記	管理者
参加者	評価者	評価者

- 管理者
  - 問題の設定
  - 必要な資料の収集・提供
  - スケジュールの策
  - 評価者からのリスク評価対象に対する質問への回答
  - 評価者の誘導
  - 報告書の作成
- 評価者
  - 危険因子の書き込み
  - 経験に基づくリスク評価（発生頻度・被害の深刻さの分類から危険因子に当てはまるものを選択）

WebHiRAS (3)
（電子航法研究所の試み）

- 長所
  - 参加者がいつでも好きなときに参加できる
  - 隔地でも簡便安価に接続できる
  - 長時間にわたる意見収集が可能
  - 別途発言内容を記録せずとも，書き込まれた内容がそのまま記録となる
- 短所
  - パソコン等に不慣れな参加者にとっては使い辛い →デザインで対応
  - 他の参加者の発言内容がWebにアクセスしない限り確認できない →自動メール送信機能

まとめ(1)

- 安全管理システム
  - 4本の柱
    - 安全方針・安全目標
    - 安全リスク管理(事前)
    - 安全保証(事後)
    - 安全推進
  - 成熟度
    - 受動的
    - 積極的
    - 予測的

まとめ(2)

- 安全管理・安全評価ツール
  - 安全報告制度・安全情報データベース
  - Human In The Loop (HITL)シミュレーション
  - 事象木，故障木，蝶ネクタイ
  - 構造化ミーティング
  - PDARS(安全保証)
- 電子航法研究所の試み WebHiRAS

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- Antonini, A., Karmarque, Y., HITL Safety Experiments Guide, EUROCNTROL実験センター, 2004

ご清聴ありがとうございました

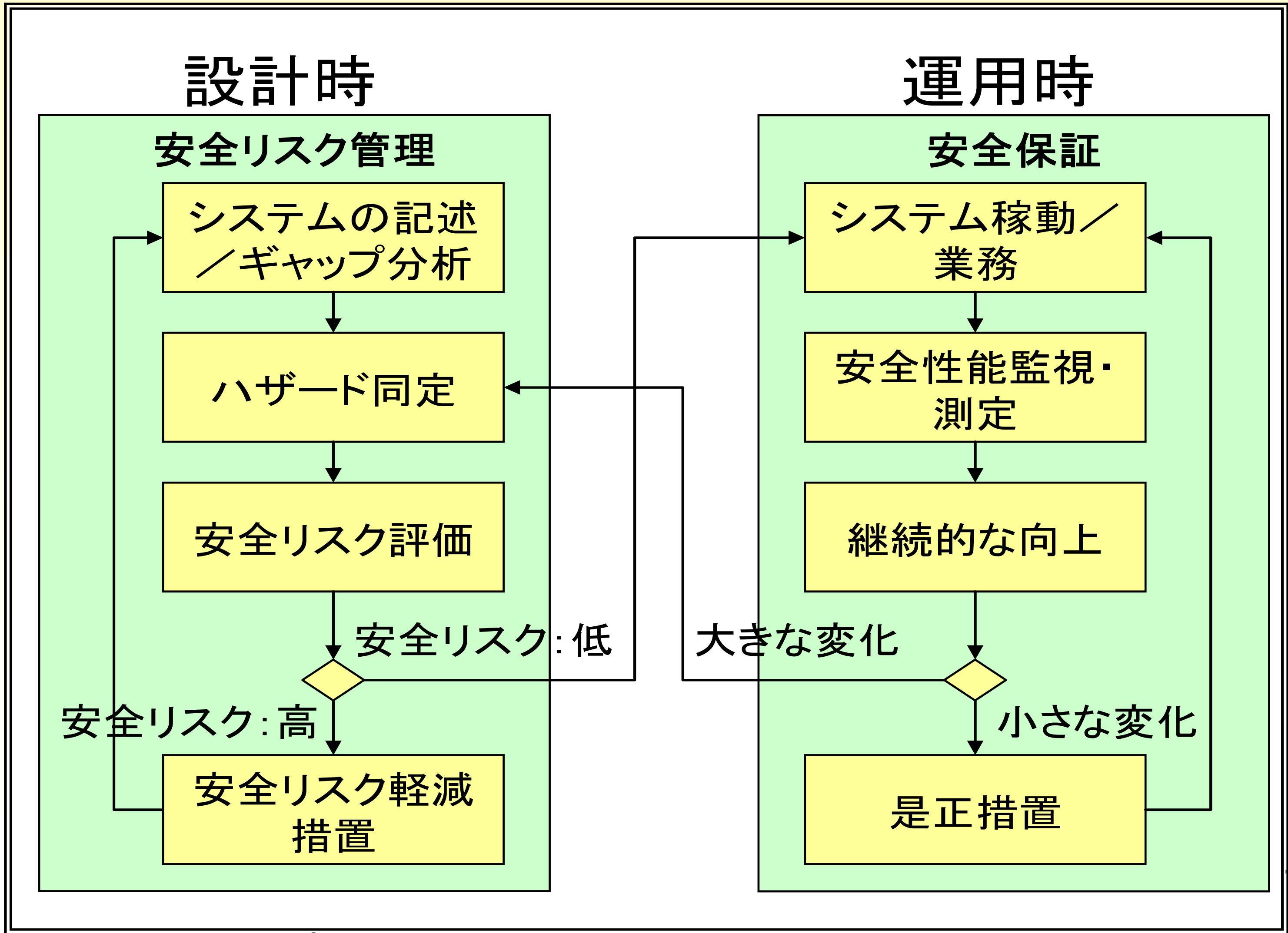
ENRI

バックアップスライド

FAA/EUROCONTROL ATM Safety Techniques and Toolbox

1. Air-MIDAS
2. Air Safety Database
3. ASRS (Aviation Safety Reporting System)
4. Bias & Uncertainty Assessment
5. Bow-Tie Analysis
6. CCA (Common Cause Analysis)
7. Collision Risk Models
8. ETA (Event Tree Analysis)
9. External Events Analysis
10. FAST (Future Aviation Safety Team) Method
11. FMECA (Failure Modes Effects and Criticality Analysis)
12. FTA (Fault Tree Analysis)
13. Future Flight Central
14. HAZOP (Hazard and Operability study)
15. HEART (Human Error Assessment and Reduction Technique)
16. HERA (Human Error in ATM)
17. HTA (Hierarchical Task Analysis)
18. HTRR (Hazard Tracking and Risk Resolution)
19. Human Error Database
20. Human Factors Case
21. PDARS (Performance Data Analysis and Reporting System)
22. SADT (Structured Analysis and Design Technique)
23. SAFSIM (Safety in Simulations)
24. SIMMOD Pro
25. TOPAZ accident risk assessment methodology
26. TRACER-Lite
27. Use of Expert Judgment

安全リスク管理と安全保証の関係



頻度分類例

頻度分類	頻度
ありうる	1日に1回起こる
起こりそうにない	1年に1回起こる
全く起こりそうにない	100年に1回起こる
ありえない	100年に1回も起こらない

深刻さ分類例

深刻さ分類	1	2	3	4	5
影響	安全マージンの完全な喪失	安全マージンの大幅な喪失	安全マージンの喪失	安全マージンの軽微な喪失	安全に対する影響なし
影響の例	以下に例示される事故 ・単独／複数の壊滅的な事故 ・単独／複数の空中衝突 ・単独／複数の地上での航空機同士の衝突 ・単独／複数の管制下・操縦可能状況下での進入禁止区域への侵入 ・完全に操縦不可能 監視や交通管制・操作手順等の事故を防止するような（考察対象となっている危険源とは）独立な回復手段がない	以下に例示される重大なインシデント ・操縦士・管制がコントロールしていない状況ないしそのような状況から回復できない状況での大きな管制間隔（例：管制間隔基準の半分以上）の喪失 ・単独／複数の航空機のクリアランスからの逸脱で、事故の回避（やその他回避行動が求められる）のため急激な衝突回避行動や進入禁止区域進入回避行動が必要	以下に例示されるインシデント ・操縦士・管制がコントロールしている状況ないしそのような状況から回復できる状況での大きな管制間隔（例：管制間隔基準の半分以上）の喪失 ・操縦士・管制がコントロールしていない状況ないしそのような状況から回復できない状況での小さな管制間隔（例：管制間隔基準の半分以下）の喪失。（衝突回避行動や進入禁止区域進入回避行動なしでは）そのような状況から回復することが出来ない。	以下に例示されるインシデント ・安全に直接の影響はないが、管制官や操縦士のワークロードの増加やCNSシステムの機能低下等により、間接的に安全に影響のある状況 ・操縦士・管制がコントロールしている状況ないしそのような状況から回復できる状況での小さな管制間隔（例：管制間隔基準の半分以下）の喪失	運航に直接・間接の影響がない状態