Post-Ejection Reporting: A Questionnaire Approach

SAFE Europe 2022
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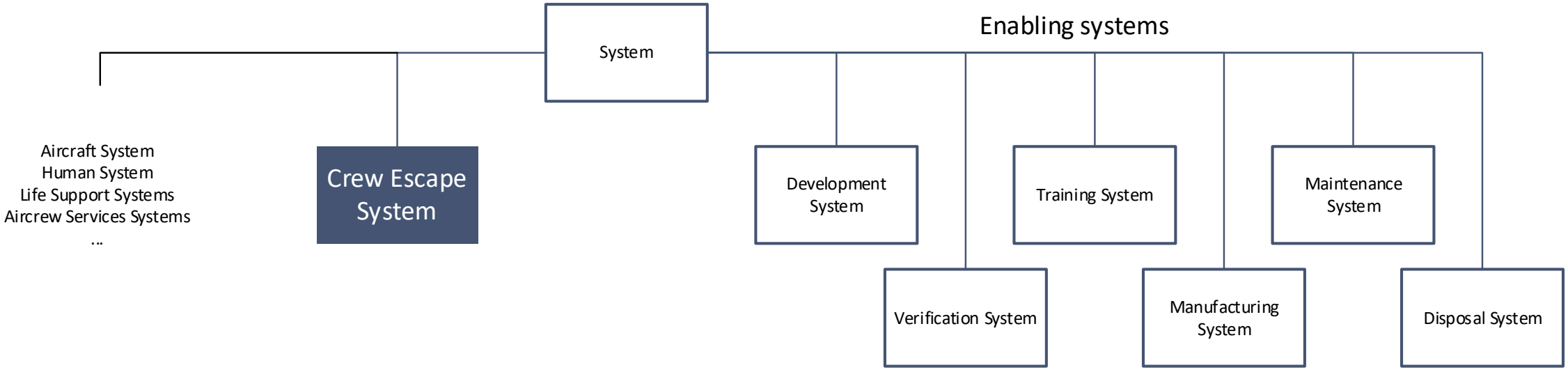
Human Systems Integration at Martin-Baker

- Crew must be an integral part of the crew escape system (CES) full lifecycle
  - Not an after-thought
  - **Holistic** view of the **total system**
- Identification of all **human interactions** with the System of Interest and all enabling systems at all stages of the lifecycle
  - Better capture of pains/gains, requirements, needs, CONOPS… right from the start of any new programme
  - **Human-in-the-loop** requirements
  - **Human-minded** designs and technologies



Human Factors Engineering

- Optimise **human to <u>all</u> system** interfaces
- Careful aircrew integration as part of cockpit design and accommodation early on in lifecycle
- Improved mission **comfort for 9+ hrs** mission duration

Optimised human performance and total system performance

Increased system maintainability

Training

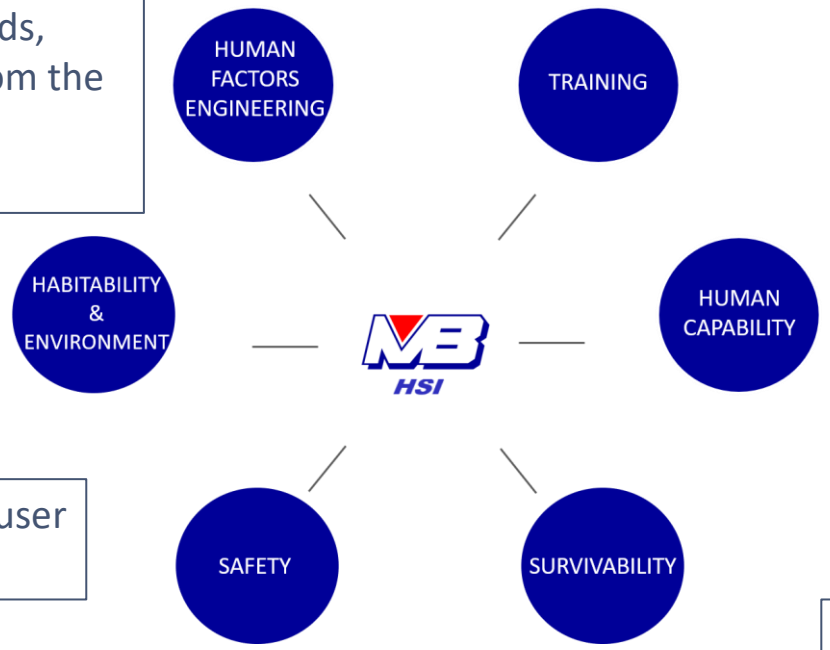
- Close the **capability gap**
- Identify skilled personnel in support of product life cycle

Better capture of pains/gains, requirements, needs, CONOPS… right from the start of any new programme

Cultural gap closure between development and operations

Habitability and Environment

- Improve the **human habitat** and **working conditions**
- **Integrated urination**, pilot cooling
- **Psychophysiological sensing** and monitoring
- **Aircrew Equipment Assemblies**



Human Capability

- Knowledge capture/information sharing processes, lessons learned
- Identify **key roles** and **capabilities** for design, manufacture, operation and maintenance

Increased user acceptance

Safety

- Ensure the system operates **reliably** and **effectively**
- Risks **identified, assessed** and **mitigated**
- **Physiological safety**

Reduced lifecycle costs

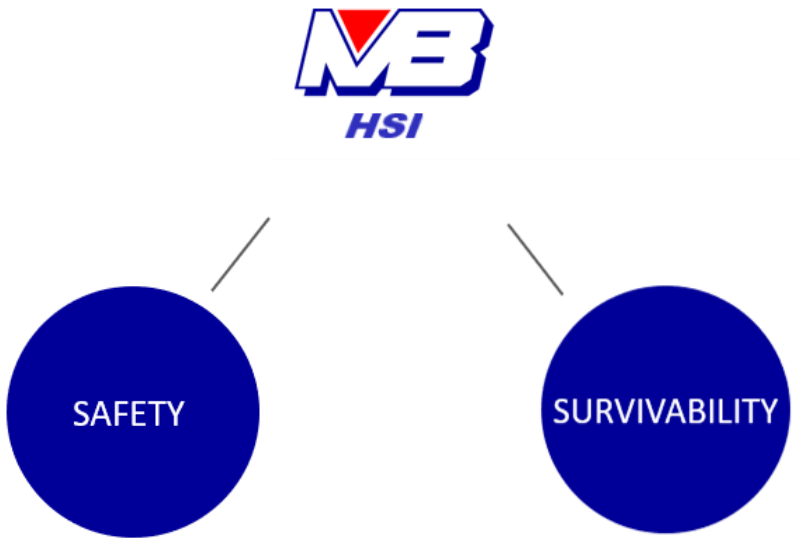
Increased system reliability

Survivability

- **Integrated protective** and **life support equipment**
- Increase ejection performance **Out of Envelope**

Collation of Post-Ejection Information

- Where can one find **lessons learned** about those areas that will bring about the greatest improvements in aircrew **safety** and **survivability**, both being MBA technical HSI domains?

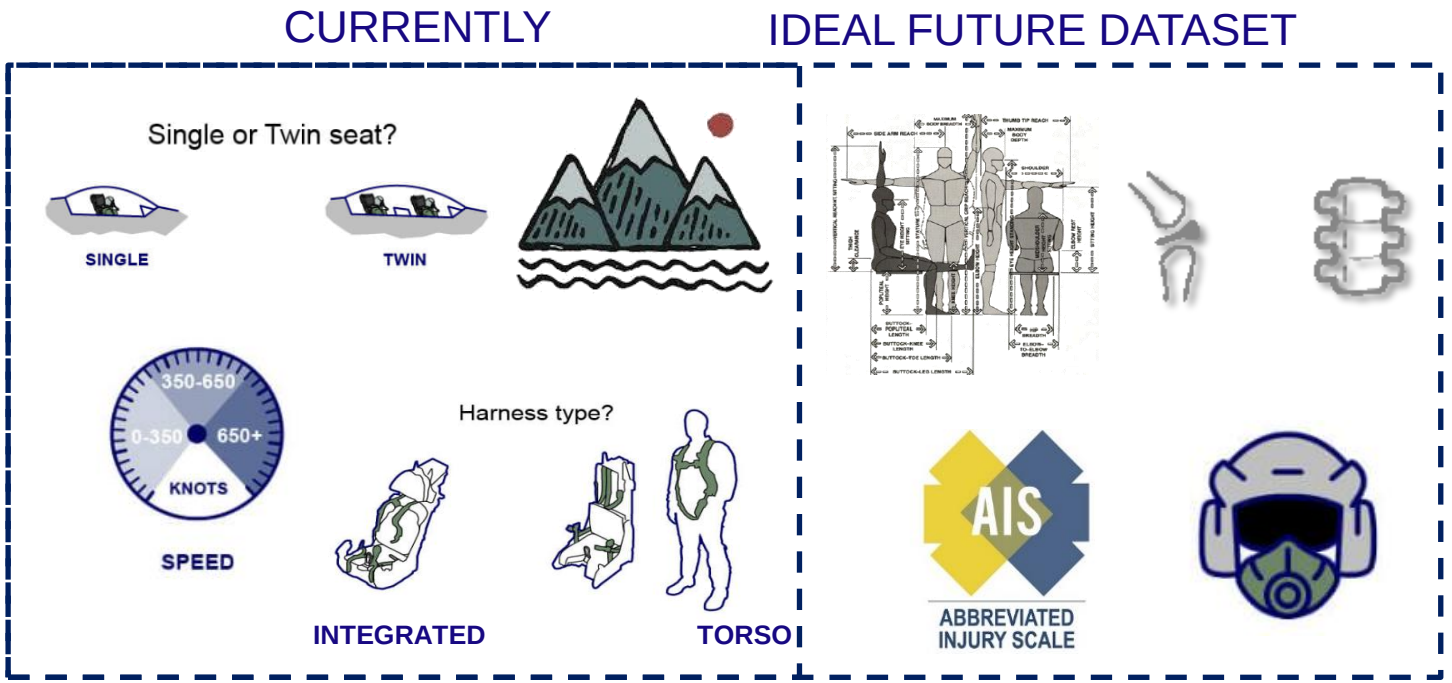


Collation of Post-Ejection Information (1/2)

- MBA ejection database is an **invaluable resource** for:
  - Identification of major drivers for **injuries** and **fatalities, potential risks** associated with escape
  - Identification of potential technical solutions, operational and equipment changes
  - Assess the overall performance and effectiveness of crew escape systems (CES) currently in operation, in order to **identify existing and emerging safety trends**
  - Input for trade studies
    - Quantifying potential improvement in **physiological aircrew safety** and in **life saving capability**
    - Analysis of impact of CES technologies
  - Reconstruct mishap scenarios, **in support of live ejection investigations** and mishap prevention
  - Data as an input for **validation of injury metrics**
    - **Challenge physiological criteria** that were not developed, for most, in the context of an escape environment
    - Verifying that the criteria is adequately representing the **real-world human data**
      - **Lack of biofidelity** of test dummies
    - Desire to have a set of airworthiness criteria that **quantify more accurately the risk to aircrew personnel**

Collation of Post-Ejection Information (2/2)

- MBA ejection records: large quantity and variety of seat types but can sometimes **lack detail on individual ejections**
  - Would benefit from **formalized regular and comprehensive disclosure** of some of the information contained in the mishap post-investigation reports
- **Level of post-ejection medical surveillance** undertaken by different operators is extremely **variable**
  - **Inconsistent and un-coordinated nature** of the classification and recording criteria
- Foster **stronger cooperation** within our **aeromedical communities**
- Jointly advancing common international standards on **post-ejection reporting, medical surveillance** and **injury classification**
- Collation of in-service data with **greater level of specificity**
  - Data describing the types, severity, and anatomic locations of injuries sustained



Example of Proposed Post-Ejection Reporting

- A **questionnaire-style** approach has been proposed for comprehensive post-ejection reporting.
  - Structured recording of circumstances surrounding the ejection and medical information related to any ejection-associated injuries.
- Intended to be **flexible** for maximum **user-friendliness** as well as providing rigidity with tightly constrained **multiple-choice questions**, to make available the most useful information.
- MBA understand some information might not be available or fall under certain restrictions. It is left to the discretion of each to provide any information possible or deemed useful to be shared with Martin-Baker.
- Demonstration run-through of how to fill out the developed questionnaire using **fictitious data.**
- **Feedback has started to be received on the questionnaire from Air Forces**, as we work to refine its design with the end-user to mind.

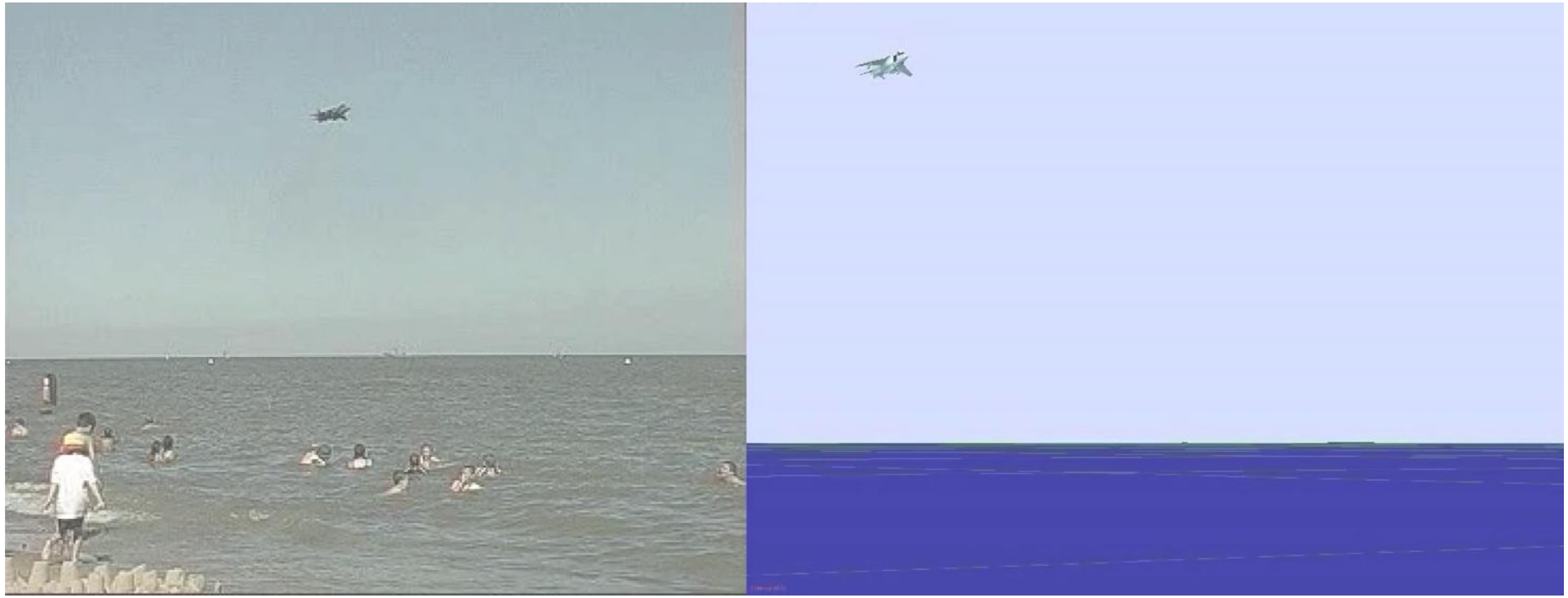
General Information about Ejection

Air Force (e.g. Royal Air Force)	Royal Air Force
Date of Ejection	2 November 2021
Aircraft Type	Harrier
Aircraft Type (Speed Range)	Up to 661 mph
Aircraft Type (Altitude Range)	0 - 38,000 feet
Flight Nature	☒ TRAINING ☐ DEMONSTRATION ☐ FERRY FLIGHT ☐ POST-MAINTENANCE CHECK ☐ OPERATIONAL DEPLOYMENT ☐ NON-OPERATIONAL DEPLOYMENT ☐ OTHER ……
Synopsis of mishap and ejection	Suspected right engine failure. Loss of aircraft control.

Reason for ejection	☐ STRUCTURAL FAILURE ☒ LOSS OF CONTROL ☐ PROPULSION SYSTEM FAILURE ☐ CONTROL SYSTEM FAILURE ☐ COLLISION ☐ ENEMY ACTION ☐ OTHER ……
Flight Phase	☐ GROUND OPERATIONS ☐ TAXI ☐ TAKE OFF ☐ INITIAL CLIMB ☒ TRANSIT ☐ MISSION EXECUTION ☐ IN-FLIGHT REFUELLING ☐ DYNAMIC MANOEUVERING ☐ APPROACH ☐ LANDING ☐ OTHER ……

General Information about Ejection

- **Example video** of mishap and ejection **reconstruction** at MBA
  - **Fictitious data**



Weather Conditions

- Meteorological information at time and location of ejection helps serve mishap reconstruction
- An online aftercast for the accident day can be used
- Weather conditions at landing site are also important (to follow) as they pertain to potential for injury on landing

Surface Temperature	17 °C
Sea-Level Pressure	1030 mbar
Wind Speed at ejection altitude	11 mph
Wind Heading	NE

Details about Ejection (1/2)

Attitude	☒ LEVEL ☐ DESCEND ☐ ASCEND	
Aircraft Descent (Sink) Rate		
Aircraft Pitch Rate	9 deg/sec (down)	
Aircraft Roll Rate	21 deg/sec (right)	
Aircraft Yaw Rate	10 deg/sec (right)	
Aircraft Acceleration		
Aircraft Angle of Attack	30 degrees nose down	or ☐ NOSE UP / ☒ NOSE DOWN
Aircraft Sideslip Angle		
Aircraft Roll Angle	Rolling right, 25 degrees right bank	or ☒ BANK RIGHT / ☐ BANK LEFT
Crew	☒ SOLO ☐ TWIN ☐ FLOWN SOLO	

Initiation method	☒ SELF ☐ COMMANDED ☐ AUTO EJECT	
Command from	☐ FRONT ☐ REAR ☐ AUTO EJECT	
ISS Mode selected		e.g., COMMAND FWD, SOLO, BOTH
Did Command system work as intended? If NO, add comments on any failure description	☐ YES ☐ NO	
If commanded, was the crew warned and ready for ejection?	☐ YES ☐ NO	

Details about Ejection (2/2)

- [1] Injuries sustained before the ejection was initiated resulting in a fatality, not the ejection itself (e.g. bird-strike injuries, mid-air collisions)
- [2] Injuries sustained/health complications after the ejection was successfully completed, which resulted in a fatality (e.g. hypothermia)
- [3] **Decisions made** *or* **incapacitations** of the occupant in the operation of, or in the use of the escape system, leading to a fatality (e.g. “Ejectee was not strapped in to the seat, and therefore not attached to the parachute”)
- [4] Used to describe cases where the cause of the fatality is unclear (e.g. “Subsequently died in hospital from injuries sustained during the ejection / landing”)

Was the ejection within seat performance envelope?	☒ YES ☐ NO ☐ UNKNOWN	☐ YES ☐ NO ☐ UNKNOWN
For an ejection within envelope, was it successful or fatal?	☒ SUCCESS ☐ FATAL	☐ SUCCESS ☐ FATAL
For an ejection out of envelope, was it successful or fatal?	☐ SUCCESS ☐ FATAL	☐ SUCCESS ☐ FATAL
Reason for fatality, if applicable	☐ OUT OF ENVELOPE ☐ ESCAPE SYSTEM MALFUNCTION ☐ MAINTENANCE ERROR ☐ PRE-EJECTION[1] ☐ POST-EJECTION[2] ☐ LANDING ☐ DROWNING ☐ HUMAN CONSIDERATIONS[3] ☐ MISCELLANEOUS[4] ☐ UNKNOWN	☐ OUT OF ENVELOPE ☐ ESCAPE SYSTEM MALFUNCTION ☐ MAINTENANCE ERROR ☐ PRE-EJECTION ☐ POST-EJECTION ☐ LANDING ☐ DROWNING ☐HUMAN CONSIDERATIONS ☐ MISCELLANEOUS ☐ UNKNOWN

Aircrew Information

	Crew member 1	Crew member 2
Nude Mass	130 lbs	
Boarding Mass	155 lbs	
Standing Height		
Sitting Height		
Age	32	
Gender	Female	
Crew Station	☐ FRONT ☐ REAR ☒ SINGLE	☐ FRONT ☐ REAR ☐ SINGLE
Speed at ejection	90 kts	
Altitude at ejection	2,000 feet	
Pilot Recovery Time (from time of ejection to first aid medical rescue team assisting crew)	20 minutes	
Seat Bucket Position from Bottom Up (Seat Height in inches or millimetres)		
Seat Tilt Adjustment Position, if applicable to ejection seat type		
Adjustable Backrest Position, if applicable to ejection seat type		
Back Spacer Fitment (additional back support pad), if applicable to ejection seat type for small crew	☐ YES, please specify: ☒ NO	☐ YES, please specify: ☐ NO

	Crew member 1	Crew member 2
Aircrew flight equipment configuration (flight suit type, gloves, immersion garment, etc.)	☐ WINTER SEA ☐ SUMMER LAND ☒ SUMMER SEA ☐ CHEMBIO ☐ OTHER	☐ WINTER SEA ☐ SUMMER LAND ☐ SUMMER SEA ☐ CHEMBIO ☐ OTHER .....
Helmet configuration inc. HMD modules details, Identification / Manufacturer		
Was the visor worn up or down?	☐ UP ☒ DOWN	☐ UP ☐ DOWN
Was the visor ripped off by the windblast?	☐ YES ☒ NO	☐ YES ☐ NO
Did the helmet remain on the head during the ejection sequence?	☒ YES ☐ NO	☐ YES ☐ NO
Were NVGs worn at ejection?	☐ YES ☒ NO	☐ YES ☐ NO
Were the NVGs fitted with auto-detach?	☐ YES ☒ NO	☐ YES ☐ NO

Landing Conditions

	Crew member 1	Crew member 2
Landing Terrain	☒ WATER ☐ LAND	☐ WATER ☐ LAND
If on LAND	☐ TREES ☐ ROCKS ☐ SAND ☐ FLAT GRASS ☐ PAVED RUNWAY ☐ OTHER	☐ TREES ☐ ROCKS ☐ SAND ☐ FLAT GRASS ☐ PAVED RUNWAY ☐ OTHER .....
If there were gusts on land at parachute landing, please provide, if possible, the Wind Gust Speed	15 mph	

Post-Ejection Survival

	Crew member 1	Crew member 2
Was the Personal Survival Pack PSP released manually or automatically? Automatic Deployment Unit (ADU) Switch Mode	☐ MANUAL ☒ AUTO	☐ MANUAL ☐ AUTO
Did the release mechanism function correctly?	☐ YES ☒ NO	☐ YES ☐ NO
Did the PSP lowering lanyard extend to its full length?	☐ YES ☐ NO ☒ PARTIALLY	☐ YES ☐ NO ☐ PARTIALLY
Did the Personal Locator Beacon (PLB) activate?	☒ YES ☐ NO	☐ YES ☐ NO
Did the liferaft inflate, if applicable?	☐ YES ☐ NO	☐ YES ☐ NO
Did the emergency oxygen system activate?	☐ YES ☐ NO Activation: ☐ AUTO ☐ MANUAL Did the system function as intended? ☐ YES ☐ NO	☐ YES ☐ NO Activation: ☐ AUTO ☐ MANUAL Did the system function as intended? ☐ YES ☐ NO
Did the life support system function correctly? Inc. release of aircraft disconnects	☒ YES ☐ NO	☐ YES ☐ NO

Aircrew Injuries (1/3)

- MBA aims to draw particular attention to examining the **type, location, incidence** and **mechanism of injuries** so as to pertain to any suggestion in modifications to the procedures and/or equipment
  - Whether particular sub-systems or equipment have particular injuries/fatalities associated with them

- Suggests the adoption of an **operationally-relevant Abbreviated Injury Scale** (AIS) as an international standardised terminology to **describe injuries** and **severity ranking**
  - Would take into account certain functional tasks that must be done by the crew to escape and evade post ejection.
  - The **ORIS scale** (NASA) combines the injury severity from the AIS as well as the crew's ability to self-egress and a measure to estimate the time to return to flight status

- Alternatively, time off flying status, days spent in hospital can help describe injury severity

- **Pre-medical conditions, physical conditions** (fit/unfit) or previous ejection history pertain to the aircrew's ability to respond to the stress of the injuries sustained depending on the aircrew's physiologic reserve

Aircrew Injuries (2/3)

	Crew member 1	Crew member 2
Fitness to fly	Fit to fly	
Any prior medical conditions?	Nothing to report	
Time off flying status, if grounded after ejection	2 weeks	
Days spent in hospital	1	
Current medical advice at the time of completing the questionnaire: is the aircrew expected to be able to resume flying in the future?	☒ YES ☐ NO	☐ YES ☐ NO
Was an MRI of the spine performed?	☒ YES ☐ NO	☐ YES ☐ NO

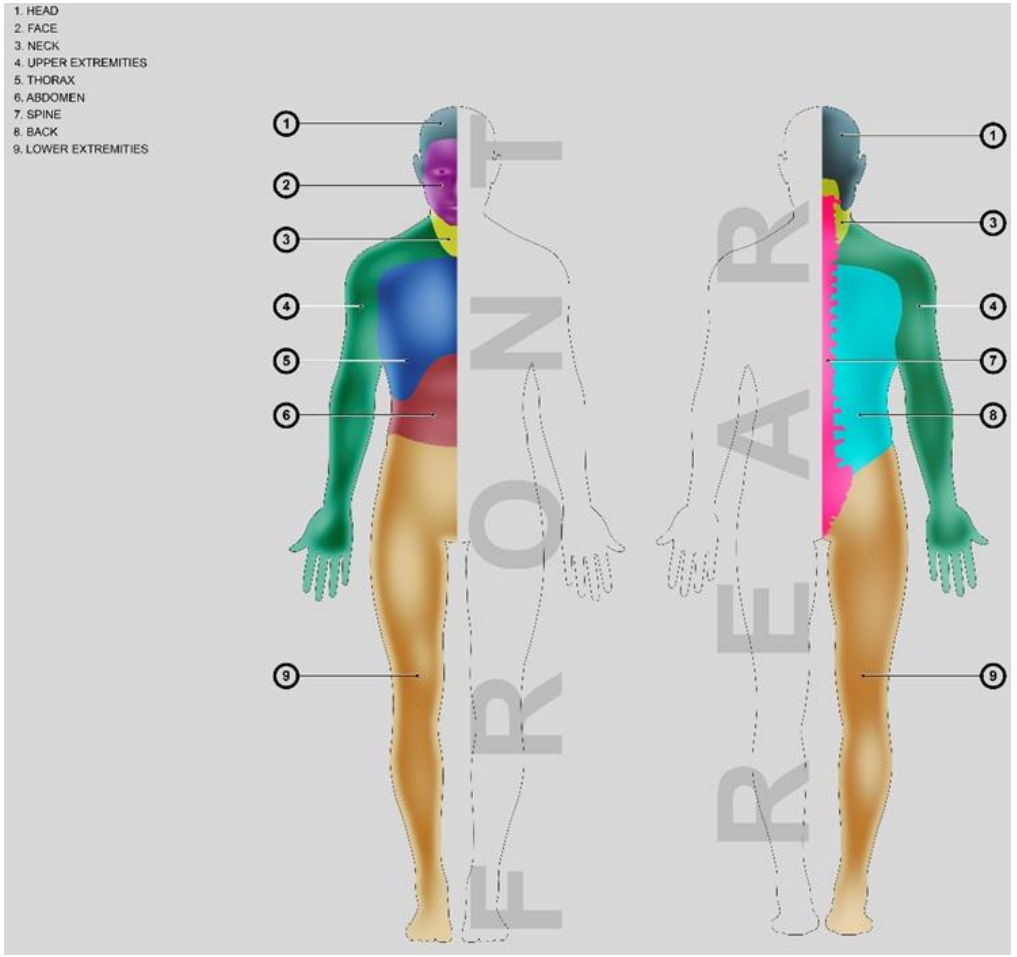
Aircrew Injuries (3/3)

- Precise **anatomical description of the injury**, as well as suspected **injury causation** (confirmed or suspected)

	Crew member 1
Injury Description (**Injury #1**) e.g., Spine, Vertebra, L1, compression fracture	Lower extremities, right ankle, sprain
AIS Severity Score Coding, if known (**Injury #1**)	
Cause (**Injury #1**)	☒ Confirmed or ☐ Suspected Cause for Injury. Please describe with as much detail as possible. Poor ankle posture on water impact.

	Crew member 1
Injury Description (**Injury #2**) e.g., Spine, Vertebra, L1, compression fracture	Spine, vertebra L5, burst compression fracture
AIS Severity Score Coding, if known (**Injury #2**)	
Cause (**Injury #2**)	☐ Confirmed or ☒ Suspected Cause for Injury. Please describe with as much detail as possible. Partially deployed PSP. Axial loading of the spine at impact.

	Crew member 1
Injury Description (**Injury #3**) e.g., Spine, Vertebra, L1, compression fracture	Lower extremities, coccyx, contusion (bruise)
AIS Severity Score Coding, if known (**Injury #3**)	
Cause (**Injury #3**)	☐ Confirmed or ☒ Suspected Cause for Injury. Please describe with as much detail as possible. Partially deployed PSP. Axial loading of the spine at impact.

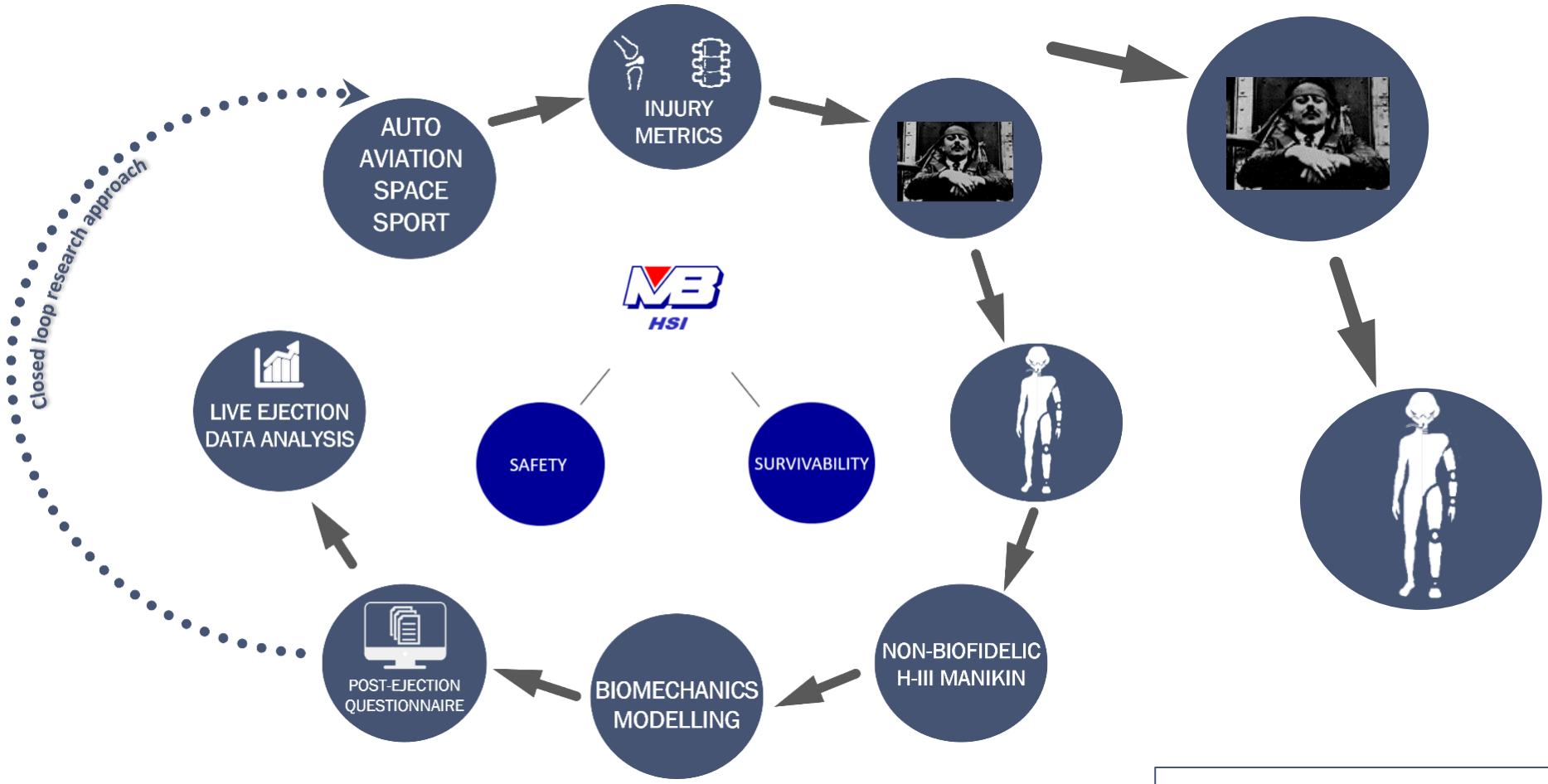


Further General Information about Crew Escape System

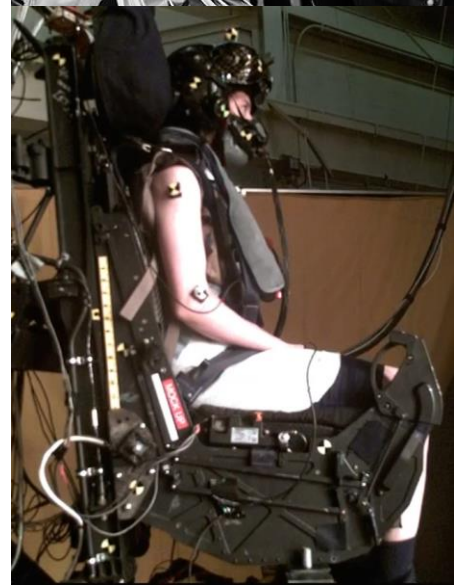
	Crew member 1	Crew member 2
Seat Mark (e.g., Mk16) and Seat Type (e.g. 10A)	Mk12, 12H	
Seat time in service	10 years	
Seat last maintenance date	October 2020	
Description of seat damage pre-ejection if any	None	
Description of seat subsystem failures or anomalies if any	PSP lowering lanyard did not deploy fully. Suspected failure of Automatic Deployment Unit.	
Firing Handle Type Pulled	☒ SEAT PAN ☐ FACE SCREEN	☐ SEAT PAN ☐ FACE SCREEN
Did the Leg Restraint function as intended?	☒ YES ☐ NO	☐ YES ☐ NO
Did the Arm Restraint, if applicable, function as intended?	☒ YES ☐ NO	☐ YES ☐ NO
Harness Type	☐ MAN-MOUNTED (e.g., Torso Harness) ☒ SEAT-MOUNTED (e.g., Integrated/Simplified Combined Harness)	☐ MAN-MOUNTED (e.g., Torso Harness) ☐ SEAT-MOUNTED (e.g., Integrated/Simplified Combined Harness)
Did the Neck Protection Device (NPD), if present, function as intended?	☐ YES ☐ NO	☐ YES ☐ NO

Description of any damage to parachute, if any	None	
When was parachute last repacked?	October 2020	
Was the Manual Over Ride (MOR) handle used?	☐ YES ☒ NO	☐ YES ☐ NO
Was the sequencer data retrieved, if applicable?	☐ YES ☐ NO	☐ YES ☐ NO
Method of Transparency Removal	☐ Jettison CJS (Rocket-assisted, aerodynamic release) ☒ Fragilization / Fragmentation (MDC) / Fracture CFS ☐ Severance CSS / Cutting (Flexible Linear-Shaped Charge FLSC) ☐ Through Canopy. If through canopy, what were the canopy penetrators condition like?	
Was the transparency removed successfully?	☒ YES ☐ NO	
Evidence of flight equipment witness marks as a result of transparency (canopy) removal?	☒ YES ☐ NO	☐ YES ☐ NO
Evidence of canopy contact with helmet?	☐ YES ☐ NO	☐ YES ☐ NO
Description of any failure		
Any unfired cartridges? If so, how were they dealt with?	☐ Operator EOD ☐ Martin-Baker field personnel Please specify which cartridges, if possible.	
Further information	For example, cartridges (or rocket motor) in-life versus out of life, failed to fire, etc.	

Where does this questionnaire fit within Martin-Baker engineering research activities?



Unethical human testing considerations



Where does this questionnaire fit within Martin-Baker engineering research activities?

NON-BIOFIDELIC
H-III MANIKIN

Lack of sufficient biofidelity in current state-of-the-art aerospace manikins

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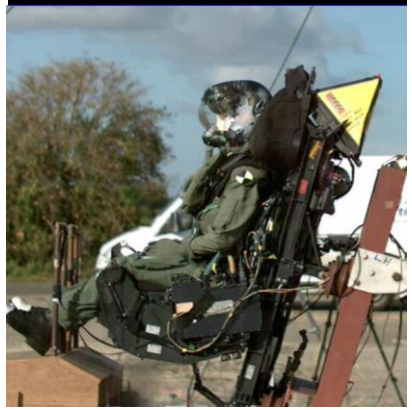
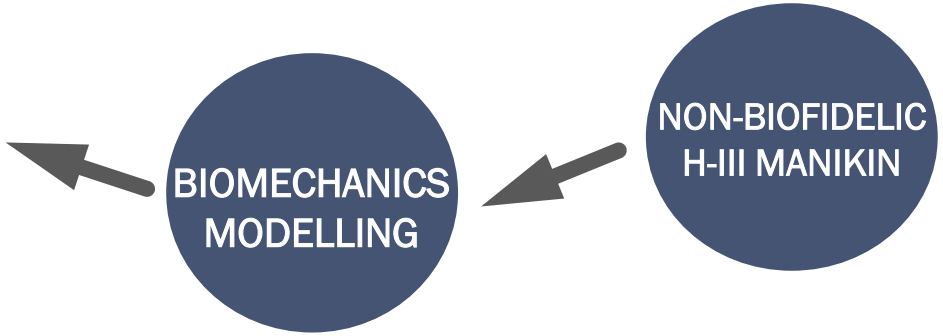


Real-world risk? (for a human)



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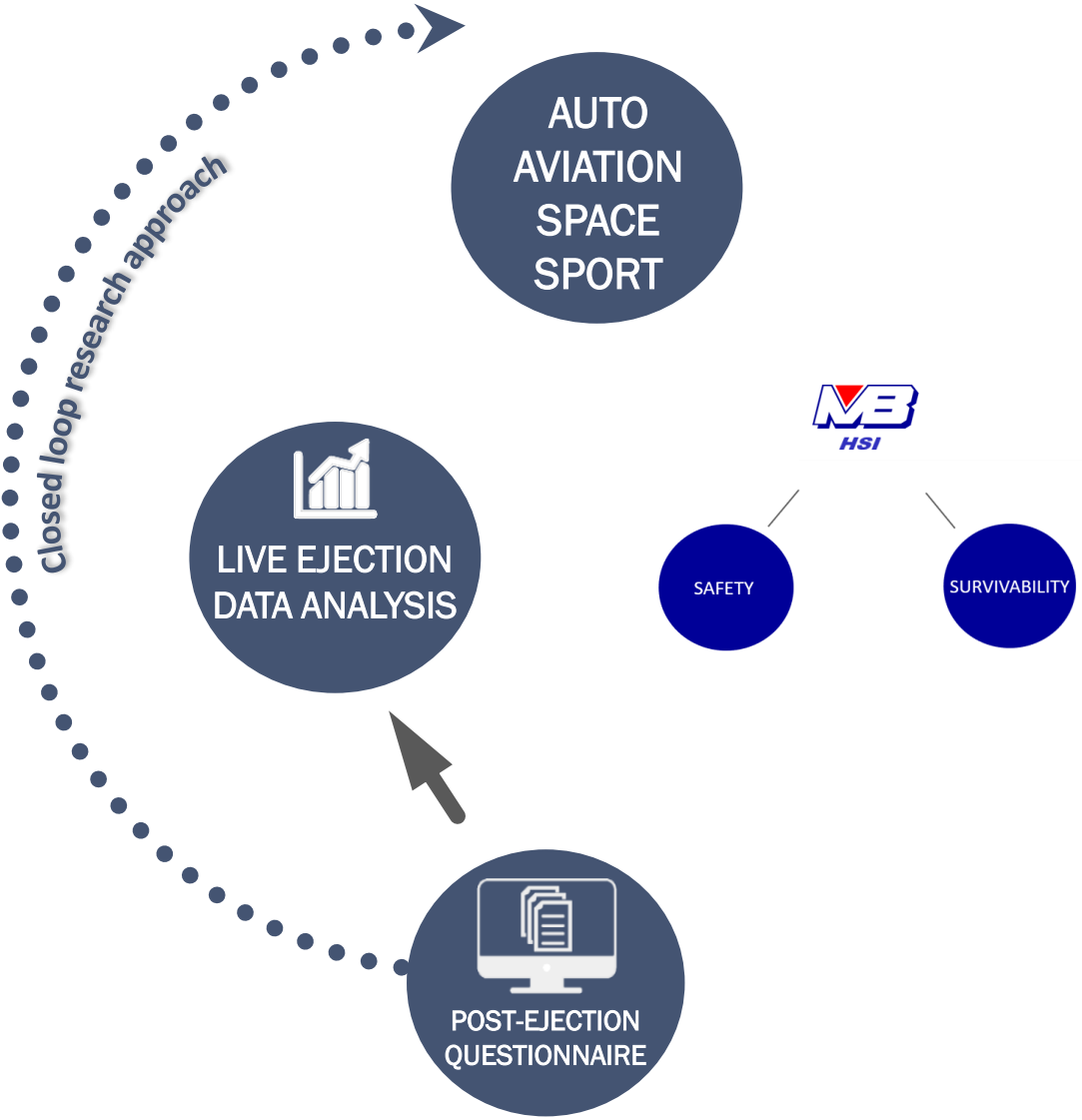

- **Real-world** risks identification
  - Physiological **safety** and **survivability**
  - Importance of gathering as much data as possible from live ejections with modern escape systems
  - Challenge physiological criteria that were not developed for most in the context of an escape environment, or without validating them against real world data; to bridge that gap
  - When live experience data is available: **re-validation of metrics should take place**

- Power of **scientific/medical data** to make **informed design recommendations**: enhanced performance, effectiveness and safety
  - Quantifying improvement in **life saving capability/technologies**
  - Informs technology development **needs**
  - *c.f.* R. Saaristo (SAFE Chester 2022)

Summary

- MBA hopes that this **questionnaire** can be useful in contributing to the mishap and safety community, and accident investigators' training material

- Reinforce culture of information **sharing and learning** from both failures and successes
  - Improved and **cooperative** post-ejection reporting process
  - Enhanced future **aircrew safety**

- Real-world data to inform **validation** of current and future metrics
  - The end desire is to have a set of airworthiness criteria that quantify more accurately the risk to aircrew personnel

- **Data management** (collection and secure storing)
  - **What** data to collect?
  - **How** to store it?
  - **Who** owns it?
  - **Who** has access to it?
    - Each nation operating under different (personal) data management policies
    - Collaborating with different aeromedical safety centres
  - NATO working group? Update to STANAG 3318 AAMedP-1.7 ?
  - ICAO Accident Statistics -style?

7675

Lives saved to date

THANK YOU

Any questions?