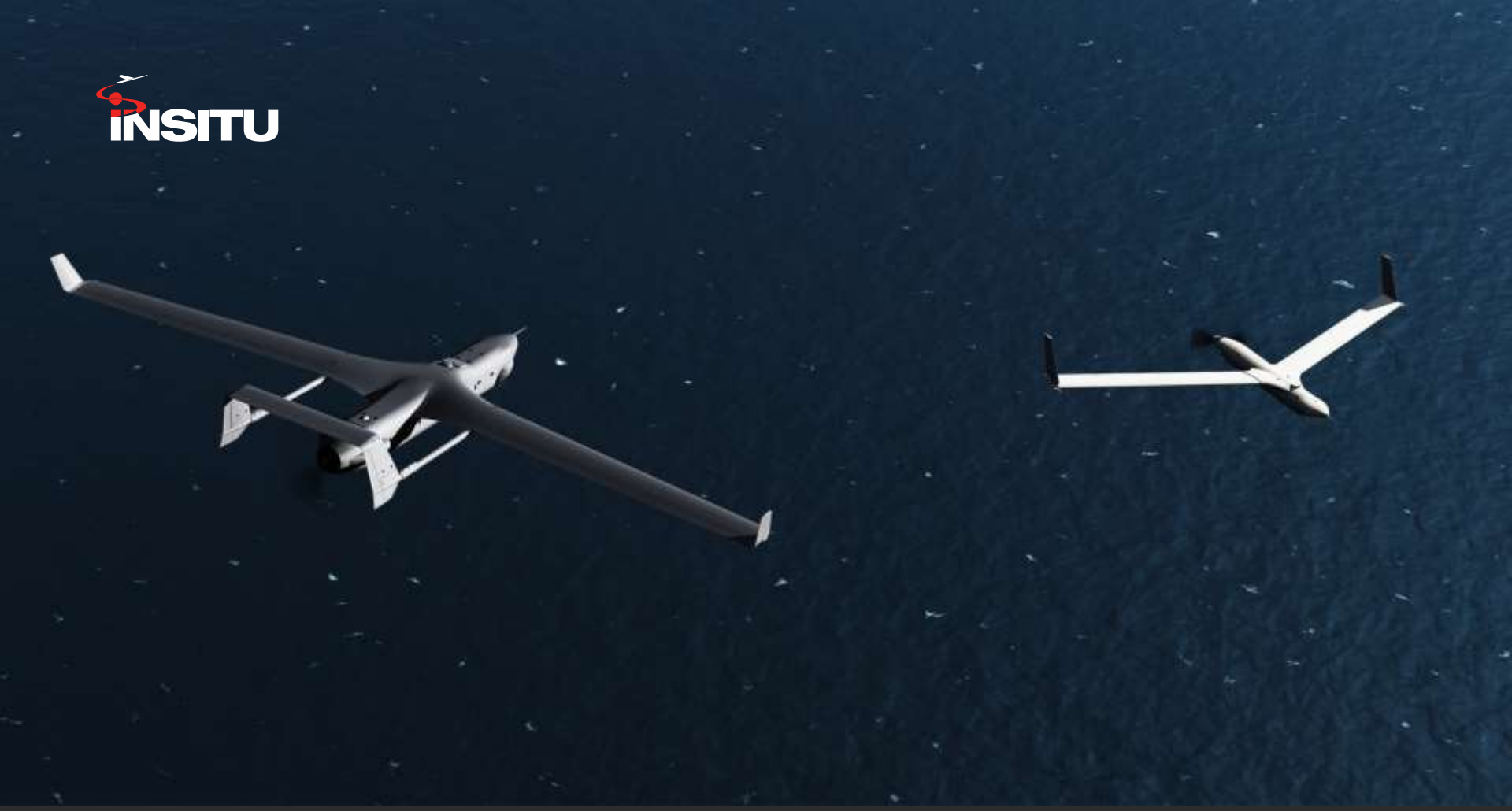

Human Factors for Unmanned Aviation Mishap Investigation:

ISASI Military Air Safety Workshop

19-Apr-2016

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Decision-making superiority delivered

Agenda

- Insitu Introduction
- Flight Safety Team and Investigations
- Human Factor Highlights
- Prevalent HFACs for UAS Operations
- Case Studies/Examples
- Questions

Insitu Snapshot

Customers:

- U.S. Marine Corps
- U.S. Navy
- U.S. Army
- U.S. Air Force
- DoD Customers
- Australia
- Canada
- Italy
- Netherlands
- Malaysia
- Singapore
- United Kingdom
- Poland
- Colombia
- Japan
- Czech Republic

871,000+ Operational Flight Hours

108,000+ Operational Sorties

42,000+ Shipboard Flight Hours

5,600+ Shipboard Sorties

Insitu is a wholly owned non-integrated subsidiary of The Boeing Company

Services

Training

Field Operations

Payloads Directorate

Products

ScanEagle®

Integrator™

ICOMC2

TacitView®

Catalina® Media Server

ScanEagle®

Weights

Empty structure weight: 30.9-39.68 lb / 14-18 kg
Max takeoff weight: 48.5 lb / 22.0 kg
Max payload weight: 7.5 lb / 3.4 kg

Performance

Endurance: 24+ hours
Ceiling: 19,500 ft / 5,944 m
Max horizontal speed: 80 knots / 41.2 m/s
Cruise speed: 50-60 knots / 25.7-30.9 m/s
Engine: heavy fuel or gasoline engine

Payload Integration

Onboard power: 60 W

Sensor and Data Options

- EO imager
- Analog or digital encrypted video datalink
- Encrypted or unencrypted C2 datalink

Integrator™

Rapid payload integration

Multi-mission capability

Weights

Empty structure weight:	80 lb / 36.28 kg
Max takeoff Weight:	135 lb / 61.2 kg
Max payload weight:	40 lb / 18 kg

Performance

Endurance:	24 hours
Ceiling:	19,500ft / 5,944 m
Max horizontal speed:	90+ knots / 46.3 m/s
Cruise speed:	55 knots / 28.3 m/s

Payload Integration

Onboard power: 350 W

Onboard connectivity

Baseline Sensor and Data Package

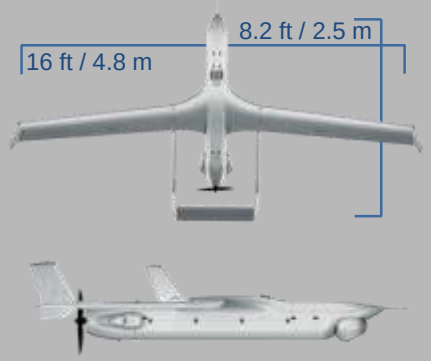
-Electro-optic imager

-Mid-wave infrared imager (MWIR)

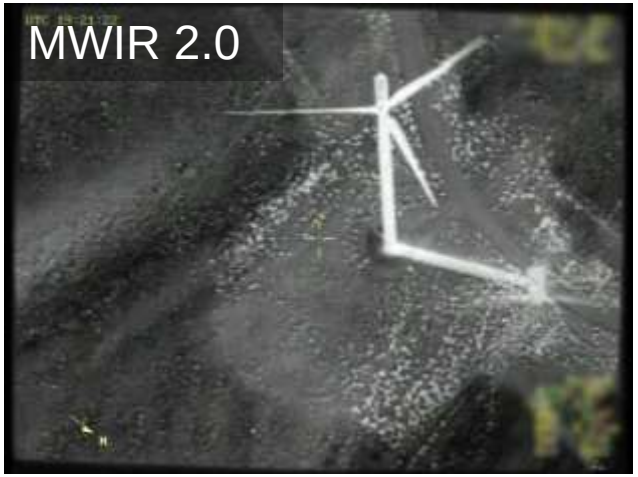
-IR marker

-Laser rangefinder

-Encrypted S-band video data



Primary Payloads



Daytime Imagery (EO600)	1.7° FOV
Daytime Imagery (EO900)	0.3º-48.7º FOV
Night Vision (MWIR 2.0)	2.0°-25° FOV
Dual Imager (MWIR & EO)	2.0º -25º /1.1º-25º FOV

Mark 4 Launcher

Expeditionary, trailer-mounted design for easy transport across rough terrain and unimproved sites

Stand-alone platform, powered by an onboard generator and compressor

Compatible with all of Insitu's unmanned aircraft; variants available for both land- and ship-based operations.

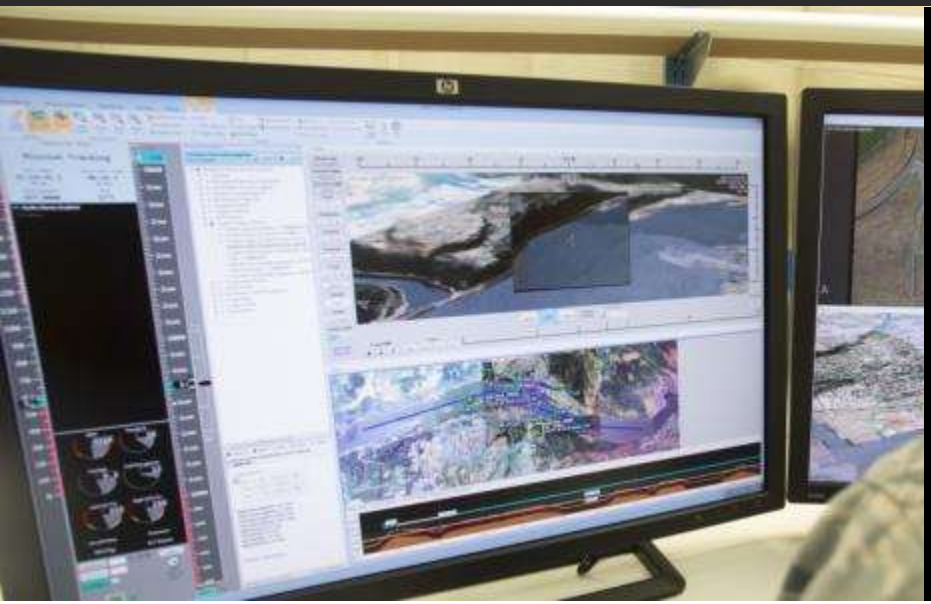
SkyHook

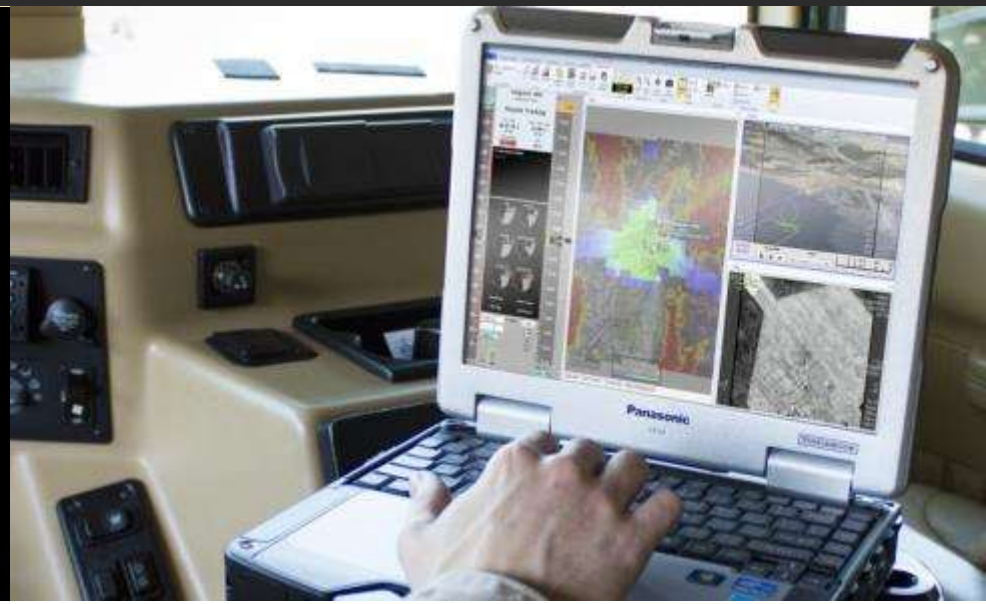
SkyHook allows recovery of the aircraft with a **very small operational footprint**.

SkyHook is **runway independent** and can accommodate a 360-degree approach path.
This allows for maximum flexibility for recovery operations in a wide range of weather conditions.

SkyHook comes in variants for both land- and ship-based operations.

ICOMC2





Small-footprint solution for command and control of unmanned vehicles and payloads.

Enables a **single operator** to operate multiple unmanned vehicles from one workstation and manage vehicle sensor command and control.

Features an **open architecture** design that is easily modified using the software development kit.

Users can create their own **customized plug-ins** and rapidly add new applications or support for new unmanned systems.

Maritime Installation

Establish a UAS capability with a flexible hub-and-spoke configuration at an offshore base, and create an ad-hoc communications networks to keep ground troops aware and informed.

45+ completed ship installations

5,000+ sorties

24/7 ops

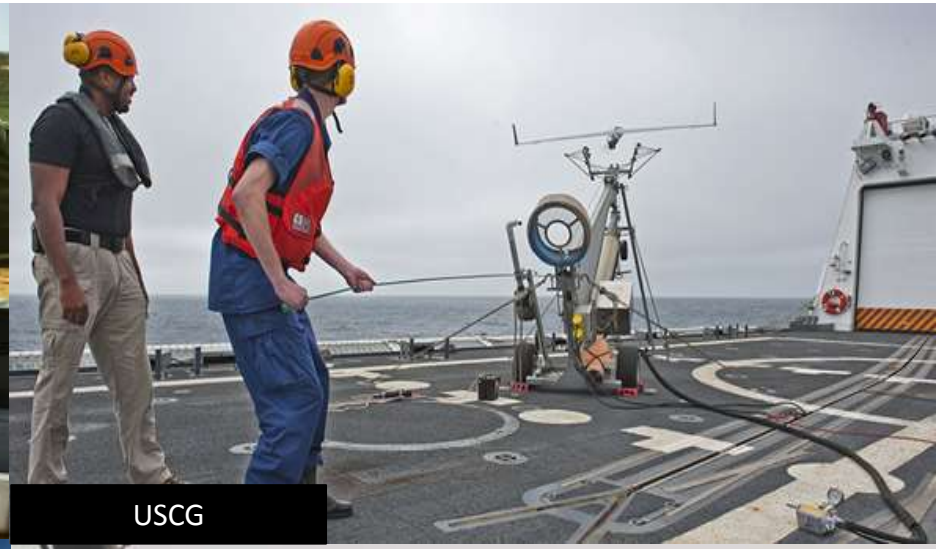
Surveillance range over **100 – 200 km**

Hub & Spoke

ScanEagle
Integrator
Target of Interest
Comms Relay
Video Relay
Target of Interest
Land-based Spoke
Comms Relay
Video Relay
Land-based HUB
ScanEagle
Target Tracking
Sea-based HUB

ScanEagle in the Field and At Sea

Foreign Military Sales



USCG

Columbian Air Force

US Warships

Insitu Flight Safety Team

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Aviation Safety Officer

Bill Kupchin

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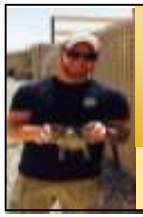

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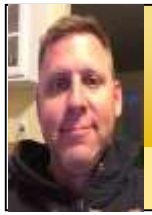

Mishap Investigator

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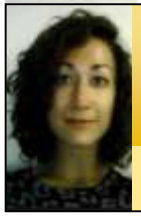

Human Factors Investigator

Gretchen Elizabeth Heath

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Typical aircraft system performance versus historical Insitu ScanEagle Performance:

- Aviation Historic Norm: Human performance issues arise after the platform has matured. In the case of Insitu, technology consistently evolved and allowed for ***concurrent Material and Human error*** manifestations.
- The expectation should be to continue observed event reduction trends, but realize the historic industry performance or better should be the target.
  - *Requires acknowledgment and acceptance that an accelerated change in the Material Failure rate as a result of technology infusion will likely plateau the Human Factors rate.*
- The desired approach is to continue the overall downward trend of current UAS event rates using a holistic systems engineering approach. This approach insinuates a manned aircraft design and development regimen and may detract from the overall idea of cost effective and expeditious. True aim should be a ***synergistic balance*** between the pros of current UAS process versus a higher reliability methodology.

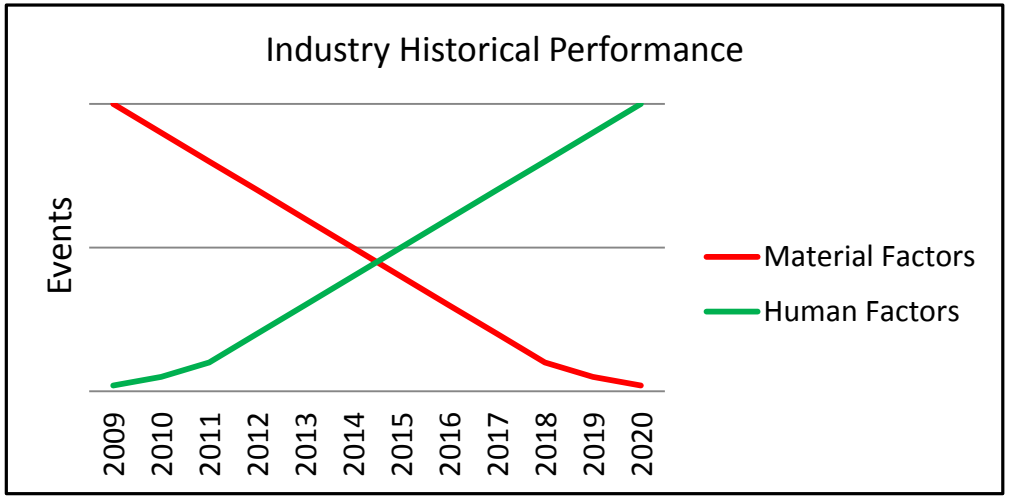


Figure 2. Aviation Human and Material Performance Chart.

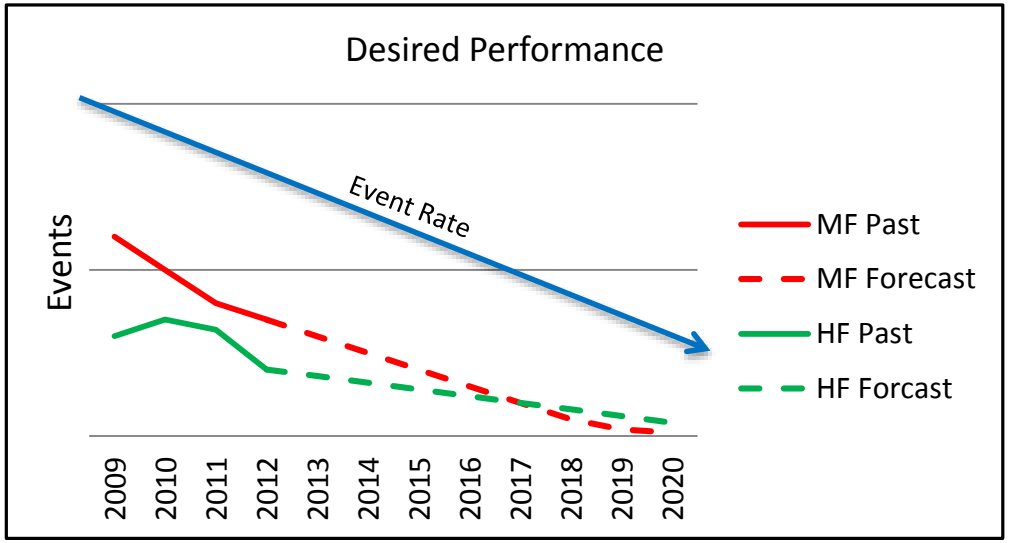


Figure 3. ScanEagle desired mishap trend performance.

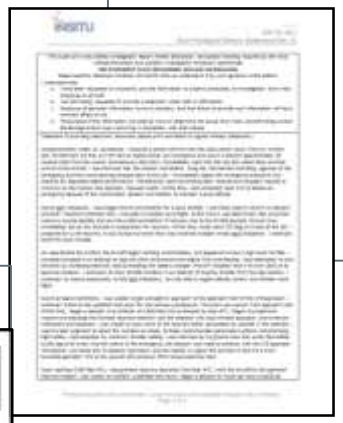
Insitu Mishap Investigation Process

Quick Overview

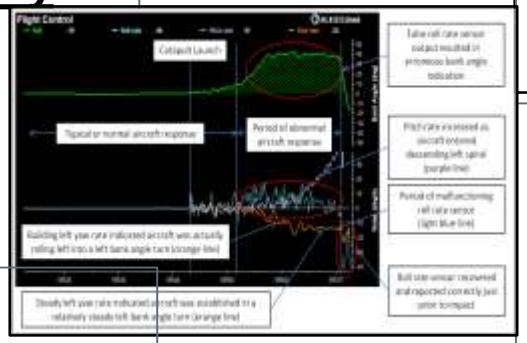
- Mishap Occurs
- Initial Reporting/Notification
- Interim Safety
- Data/Evidence Collection
- Mishap Analysis
- Findings
- Recommendations

Mishap

Witness Statements



Telemetry



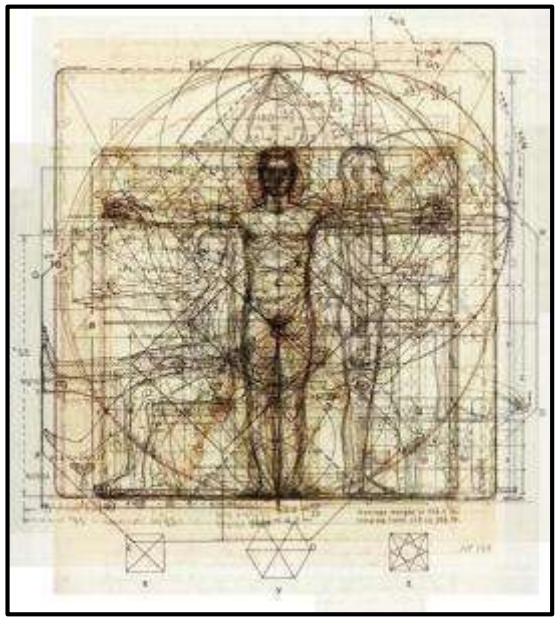
MX Documentation

Engineering Investigation

Final Report

Human Factors

- Human factors is an area of psychology that focuses on a range of different topics, including ergonomics, workplace safety, human error, product design, human capability, and human-computer interaction.
- Human factors works to apply principles of psychology to designing products and creating work environments that boost productivity while minimizing safety issues.



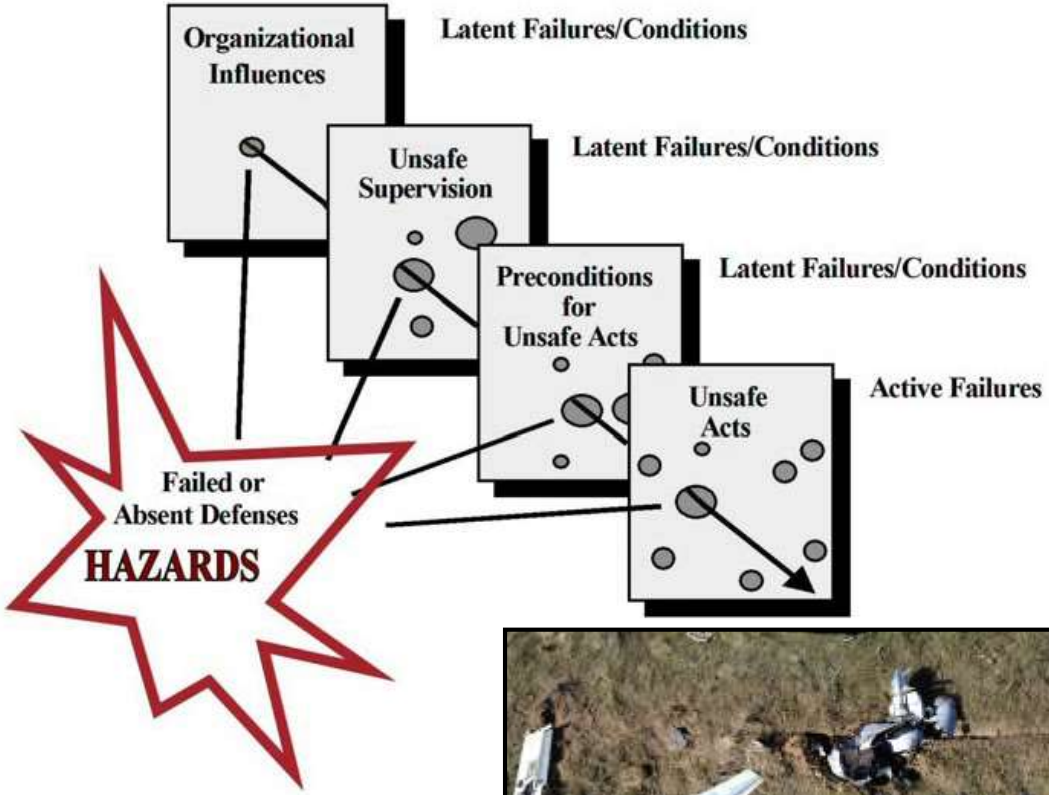
- **Reason's "Swiss Cheese" Model** describes and helps detect and identify the "holes (hazards) in the cheese". Working backward from the mishap, the first level depicts *Unsafe Acts of Operators* that ultimately lead to a mishap. *Preconditions,* such as fatigue, complacency, illness, and the physical/technological environment, all effect individual performance and can lead to unsafe acts. Likewise, *Unsafe Supervision* and *Organizational Influences* are held accountable.

- **DoD HFACS** Based on James Reason's "Swiss Cheese" Model, the Department of Defense Human Factors Analysis and Classification System (HFACS) tool was developed to identify hazards and risks. DoD HFACS describes four main tiers of failures/conditions:

  1. Unsafe Acts
  2. Preconditions
  3. Unsafe Supervision
  4. Organizational Influences

Statistical Analysis and HFACS

- Insitu uses statistical analysis of mishap rates to identify high interest areas such as high mishap rate failure modes, seasonal variances, effectiveness of procedural changes, transition of site personnel, etc.
- Top three failure modes include:
  - Engine Failure (Air/fuel, Mechanical, Ignition)
  - Recovery Failure (Rope Bounce/Disengagement, Environmental Factors)
  - Human Error (Procedural/Checklist, Situational Awareness, Complacency)



ACTS

Performance-Based Errors

Factors that occur when a specific action is performed in a manner that leads to a mishap or unsafe condition.

[AE100]

- **AE101** Unintended Operation of Equipment
- **AE102** Checklist Not Followed Correctly
- **AE103** Procedure Not Followed Correctly
- **AE104** Over-Controlled/Under-Controlled Aircraft/Vehicle/System
- **AE105** Breakdown of Visual Scan
- **AE107** Rushed or Delayed a Necessary Action

Judgment & Decision-Making Errors

Factors that occur when an individual proceeds as intended, yet the plan proves inadequate or inappropriate for the situation, e.g. "An honest mistake."

[AE200]

- **AE201** Inadequate Real-Time Risk Assessment
- **AE202** Failure to Prioritize Tasks Adequately
- **AE205** Ignored a Caution/Warning
- **AE206** Wrong Choice of Action During an Operation

Violations

Factors when the individual intentionally breaks the rules and instructions. "Violations are deliberate."

[AV000]

- **AV001** Performs Work-Around Violation
- **AV002** Commits Widespread/Routine Violation
- **AV003** Extreme Violation- Lack of Discipline

PRECONDITIONS

Environment

Physical Environment
Factors such as weather, climate, fog, brownout [dust or sad storm] or whiteout [snow storm] that affects the actions of individual.
[PE100]

- **PE101** Environmental Conditions Affecting Vision
- **PE103** Vibration Effects Vision or Balance
- **PE106** Heat/Cold Stress Impairs Performance
- **PE108** External Force or Object Impeded an Individual's Movement
- **PE109** Lights of other Vehicle/Vessel/Aircraft Affects Vision
- **PE110** Noise Interference

Technological Environment
Factors when automation or the design of the workspace affects the actions of an individual.
[PE200]

- **PE201** Seat and Restraint System Problems
- **PE202** Instrumentation & Warning System Issues
- **PE203** Visibility Restrictions [Not Weather Related]
- **PE204** Controls & Switches are Inadequate
- **PE205** Automated System Creates Unsafe Situation
- **PE206** Workplace Incompatible with Operation
- **PE207** Personal Equipment Interference
- **PE208** Communication Equipment Inadequate

Physical & Mental State

Physical Problems
Are Medical or Physiological conditions that can result in unsafe situations.
[PC300]

- **PC302** Substance Effects [Alcohol, Supplements, Meds, Drugs]
- **PC304** Loss of Consciousness [Sudden or Prolonged Onset]
- **PC305** Physical Illness/Injury
- **PC307** Fatigue
- **PC310** Trapped Gas Disorders
- **PC311** Evolved Gas Disorders
- **PC312** Hypoxia/Hyperventilation
- **PC314** Inadequate Adaptation to Darkness
- **PC315** Dehydration
- **PC317** Body Size/Movement Limitations
- **PC318** Physical Strength & Coordination [Inappropriate for Task Demands]
- **PC319** Nutrition/ Diet

State of Mind
Factors when an individual's personality traits, psychosocial problems, psychological disorders or inappropriate motivation creates unsafe situation.
[PC200]

- **PC202** Psychological Problem
- **PC203** Life Stressors
- **PC204** Emotional State
- **PC205** Personality Style
- **PC206** Overconfidence
- **PC207** Pressing
- **PC208** Complacency
- **PC209** Motivation
- **PC215** Motivational Exhaustion [Burnout]

Sensory Misperception
Factors resulting in degraded sensory inputs [visual, auditory, or vestibular] that create a misperception of an object, threat or situation.
[PC500]

- **PC501** Motion Illusion- Kinesthetic
- **PC502** Turning Illusion/Balance - Vestibular
- **PC503** Visual Illusion
- **PC504** Misperception of Changing Environment
- **PC505** Misinterpreted/Misread Instrument
- **PC507** Misinterpretation of Auditory/Sound Cues
- **PC508** Spatial Disorientation
- **PC511** Temporal/Time Distortion

Mental Awareness
Factors of an attention management or awareness failure that affects the perception or performance of individuals.
[PC100]

- **PC101** Not Paying Attention
- **PC102** Fixation
- **PC103** Task Over-Saturation/Under-Saturation
- **PC104** Confusion
- **PC105** Negative Habit Transfer
- **PC106** Distractions
- **PC107** Geographically Lost
- **PC108** Interference/ Interruption
- **PC109** Technical or Procedural Knowledge Not Retained after Training
- **PC110** Inaccurate Expectations

Teamwork
Factors refer to interactions among individuals, crews, & teams involved with the preparation & execution of a task/mission in human error or an unsafe situation.
[PP100]

- **PP103** Inadequate Task Delegation
- **PP104** Rank/Position Intimidation
- **PP105** Lack of Assertiveness
- **PP106** Critical Information Not Communicated
- **PP107** Standard/Proper Terminology Not Used
- **PP108** Failed to Effectively Communicate
- **PP109** Task/Mission Planning/Briefing Inadequate

ORGANIZATIONAL INFLUENCES

Resources Problems
Factors when processes or policies influence system safety, resulting in inadequate error management or creating an unsafe situation
[OR000]

- **OR001** Command & Control Resources are Deficient
- **OR003** Inadequate Infrastructure
- **OR005** Failure to Remove Inadequate/ Worn-out Equipment in Timely Manner
- **OR008** Failure to Provide Adequate Operational Information Resources
- **OR009** Failure to Provide Adequate Funding

Personnel Selection & Staffing
Factors if personnel management processes or policies, directly or indirectly, influence system safety resulting in poor error management or creates an unsafe situation.
[OS000]

- **OS001** Personnel Recruiting & Selection Polices are Inadequate
- **OS002** Failure to Provide Adequate Manning/ Staffing Resources

Policy & Process Issues
Factors if these processes negatively influence performance & result in an unsafe situation
[OP000]

- **OP001** Pace of Ops-Tempo/ Workload
- **OP002** Organizational Program/Policy Risks not Adequately Assessed
- **OP003** Provided Inadequate Procedural Guidance or Publications
- **OP004** Organizational [formal] Training is Inadequate or Unavailable
- **OP005** Flawed Doctrine/ Philosophy
- **OP006** Inadequate Program Management
- **OP007** Purchasing or Providing Poorly Designed or Unsuitable Equipment

Climate/ Culture Influences
Factors where the working atmosphere within the organization influences individual actions resulting in human error [e.g. command structure, policies, and working environment].
[OC000]

- **OC001** Organizational Culture [attitude/actions] Allows for Unsafe Task/ Mission
- **OP003** Organizational Over-confidence or Under-confidence in Equipment
- **OC004** Unit Mission/ Aircraft/ Vehicle/ Equipment change or Unit Deactivation
- **OC005** Organizational Structure is Unclear or Inadequate

SUPERVISION

Supervisory Violations
Factors when supervisors willfully disregard instructions.
[SV000]

- **SV001** Failure to Enforce Existing Rules
- **SV002** Allowing Unwritten Policies to Become Standard
- **SV003** Directed Individual to Violate Existing Regulations
- **SV004** Authorized Unqualified Individuals for Task

Planned Inappropriate Operations
Factors when supervision fails to adequately plan or assess the hazards associated with an operation and allows for unnecessary risk.
[SP000]

- **SP001** Directed Task beyond Personnel Capabilities
- **SP002** Inappropriate Team Composition
- **SP003** Selected Individual with Lack of Current or Limited Experience
- **SP006** Performed Inadequate Risk Assessment -Formal
- **SP007** Authorized Unnecessary Hazard

Inadequate Supervision
Factors when supervision proves inappropriate or improper and/or fails to identify hazards; recognize and control risk; provide guidance, training and/ or oversight.
[SI000]

- **SI001** Supervisory/Command Oversight Inadequate
- **SI002** Improper Role-modeling
- **SI003** Failed to Provided Proper Training
- **SI004** Failed to Provide Appropriate Policy/ Guidance
- **SI005** Personality Conflict with Supervisor
- **SI006** Lack of Supervisory Responses to Critical Information
- **SI007** Failed to Identify/ Correct Risky or Unsafe Practices
- **SI008** Selected Individual with Lack of Proficiency

Failure Mode Nomenclature

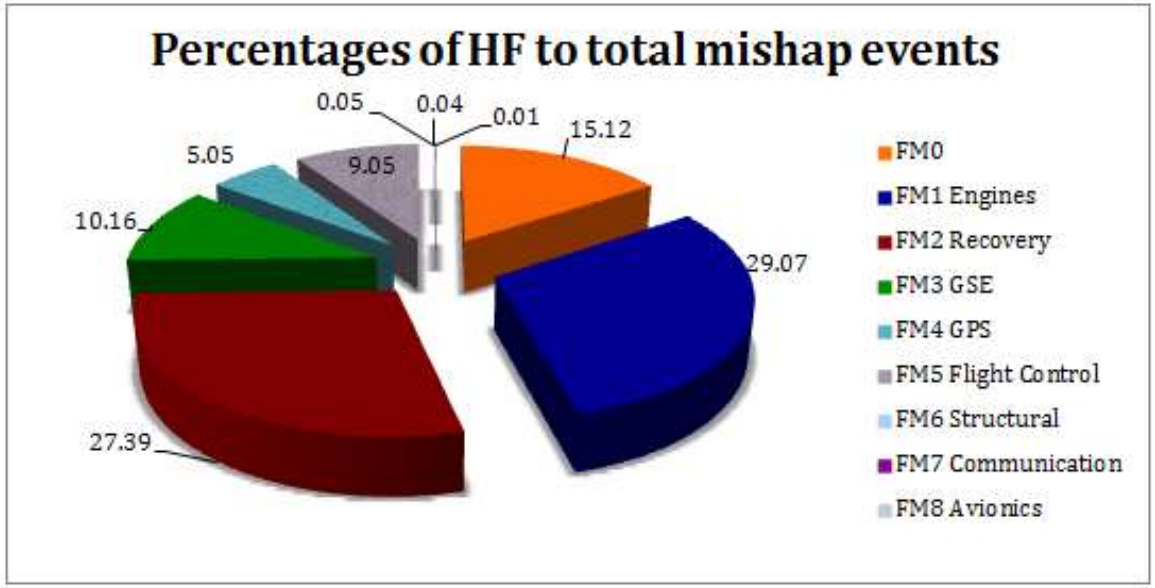
Failure Mode Codes

The Insitu flight Safety Group used eight primary failure categories to classify UAS mishap events, these include; Engines, Recovery, Ground Support Equipment (GSE), Global Positioning Satellite (GPS), Flight Controls, Structural, Communications, and Avionics. Once a primary failure category is established the failure mode is further broken down into sub failure categories or specific failure types. A codification schema using a four-digit identifier such as ***FM1A*** is used for categorization purposes and to later analyze total failures by their respective modes. The code can be interpreted as such; (FM) for failure mode, 0-8 to identify the primary system or module, and a fourth Alpha character to identify the specific component or failure type. A graphic depiction of the failure mode code is illustrated in *figure 1*.

FM1A (FM) Failure Mode; (1) Engines; (A) Ignition System

Figure 1. Insitu Failure Mode Code.

Overview of Primary Failure Categories



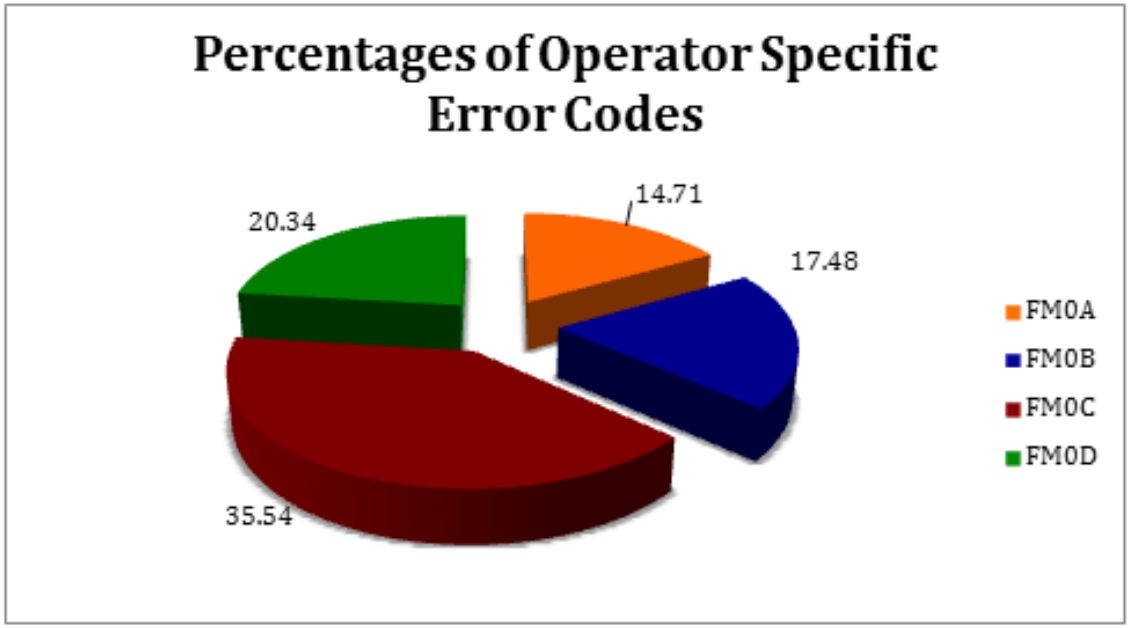
A review of the primary failures for the total flight experience yielded that Human Factors specific mishaps accounted for 15.21% of total mishaps. The various failure modes will be explored more extensively in the following paragraphs.

Table 1. Percentage of each failure mode relative to total failures.

Human Factors FM0	15.12%
Engine Failures FM1	29.07%
Recovery Failures FM2	27.39%
Ground Support Equipment Failures FM3	10.16%
GPS Failures FM4	5.05%
Flight Control Failures FM5	9.05%
Structural Failures FM6	00.05%
Communications Failures FM7	00.04%
Avionics Failures FM8	00.01%

Percentages of Primary Human Factors Codes to total mishap events

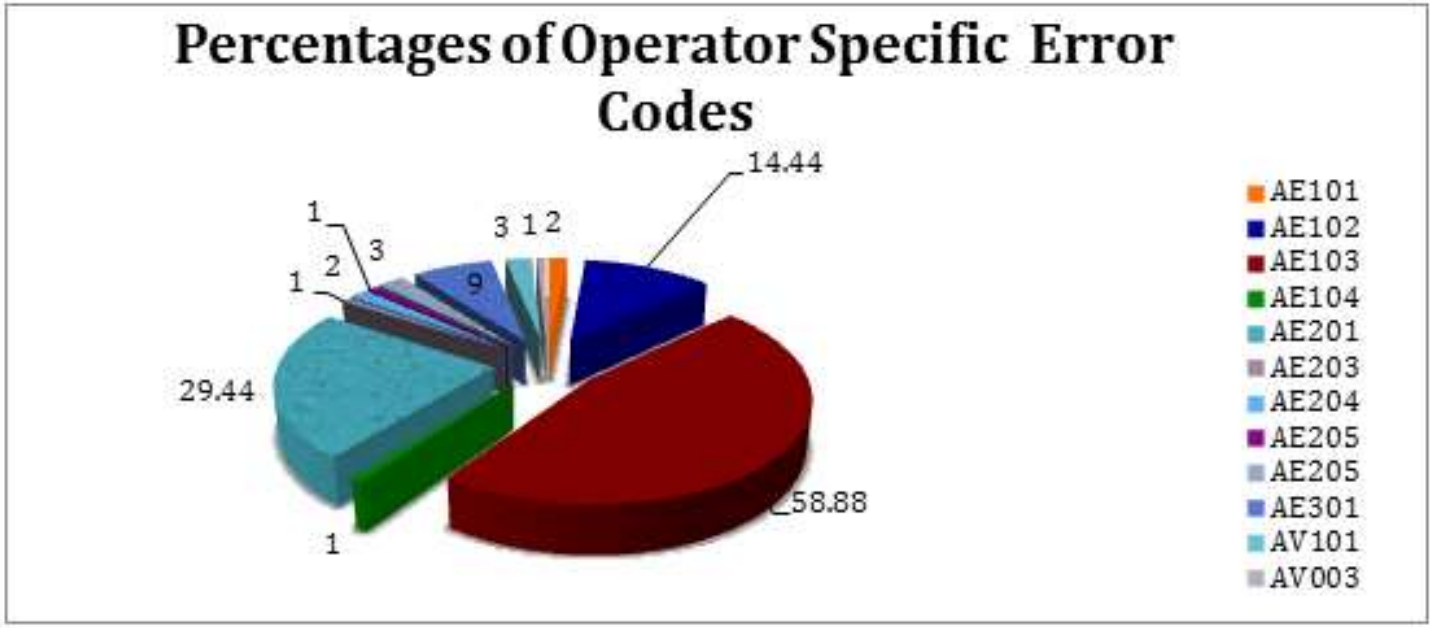
Human Factors FM0	Percentages
Operator Error – Controlled Flight Into Terrain FM0A	14.71
Operator Error – Check List Error FM0B	17.48
Operator Error – Communication FM0C	35.54
Operator Error – Procedural Error FM0D	20.34



Percentages of Human Factors Acts to total Human Factor Mishap Events

Human Factors FM0A – FM0D	Percentages
AE101 Inadvertent Operation	02.00
AE102 Checklist Error	14.44
AE103 Procedural Error	58.88
AE104 Over Control Under Control	01.00
AE201 Risk Assessment During Operation	29.44
AE203 Necessary Action – Rushed	01.00
AE204 Necessary Action – Delayed	02.00
AE205 Caution/ Warning Ignored	01.00
AE206 Decision Making During Operations	03.00
AE301 Error Due to Misperception	09.00
AV101 Violation – Based on Risk Assessment	03.00
AV003 Violation – Lack of Discipline	01.00

59% AE103 Procedural Error
29% AE201 Risk Assessment During Operations
14% AE102 Checklist Error



Common Unsafe Acts in UAS Operations

- **Checklist Error**
  - Checklist Error is a factor when the individual, either through an act of commission or omission makes a checklist error or fails to run an appropriate checklist and this failure results in an unsafe situation.

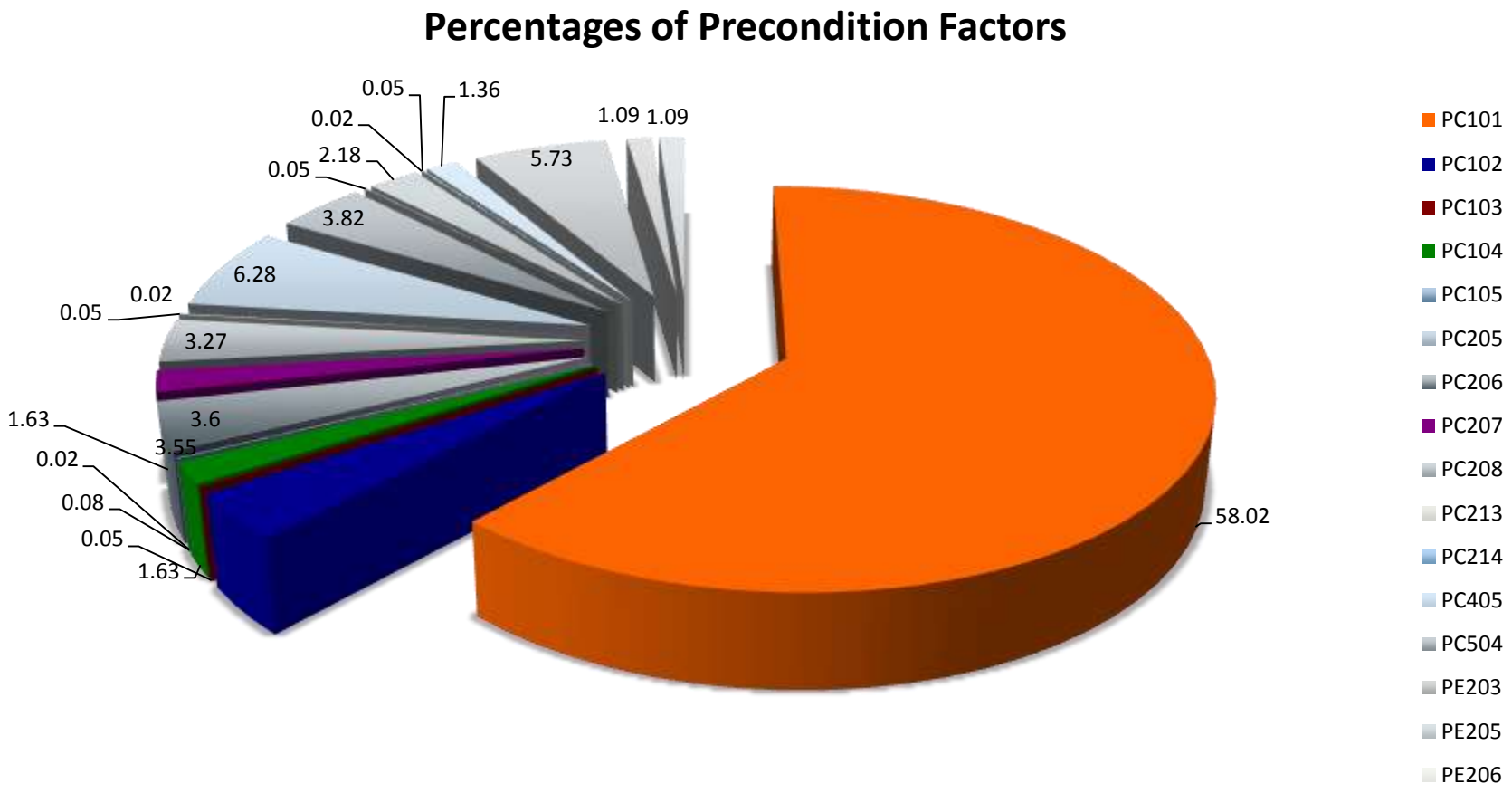
- **Procedural Error**
  - Procedural Error is a factor when a procedure is accomplished in the wrong sequence or using the wrong technique or when the wrong control or switch is used. This also captures errors in navigation, calculation or operation of automated systems.

- **Risk Assessment During Operation**
  - Risk Assessment During Operation is a factor when the individual fails to adequately evaluate the risks associated with a particular course of action and this faulty evaluation leads to inappropriate decision and subsequent unsafe situation. This failure occurs in real-time when formal risk-assessment procedures are not possible.

- **Decision-Making During Operation**
  - Decision-Making During Operation is a factor when the individual through faulty logic selects the wrong course of action in a time-constrained environment.

- **Error due to Misperception**
  - Error due to Misperception is a factor when an individual acts or fails to act based on an illusion; misperception or disorientation state and this act or failure to act creates an unsafe situation.

Precondition Factors



58% PC101 Inattention

6.3% PC405 Technical/Procedural Knowledge

6% PP102 Cross-Monitoring

Common Preconditions in UAS Operations

- **Inattention**
  - Inattention is a factor when the individual has a state of reduced conscious attention due to a sense of security, self-confidence, boredom or a perceived absence of threat from the environment which degrades crew performance.

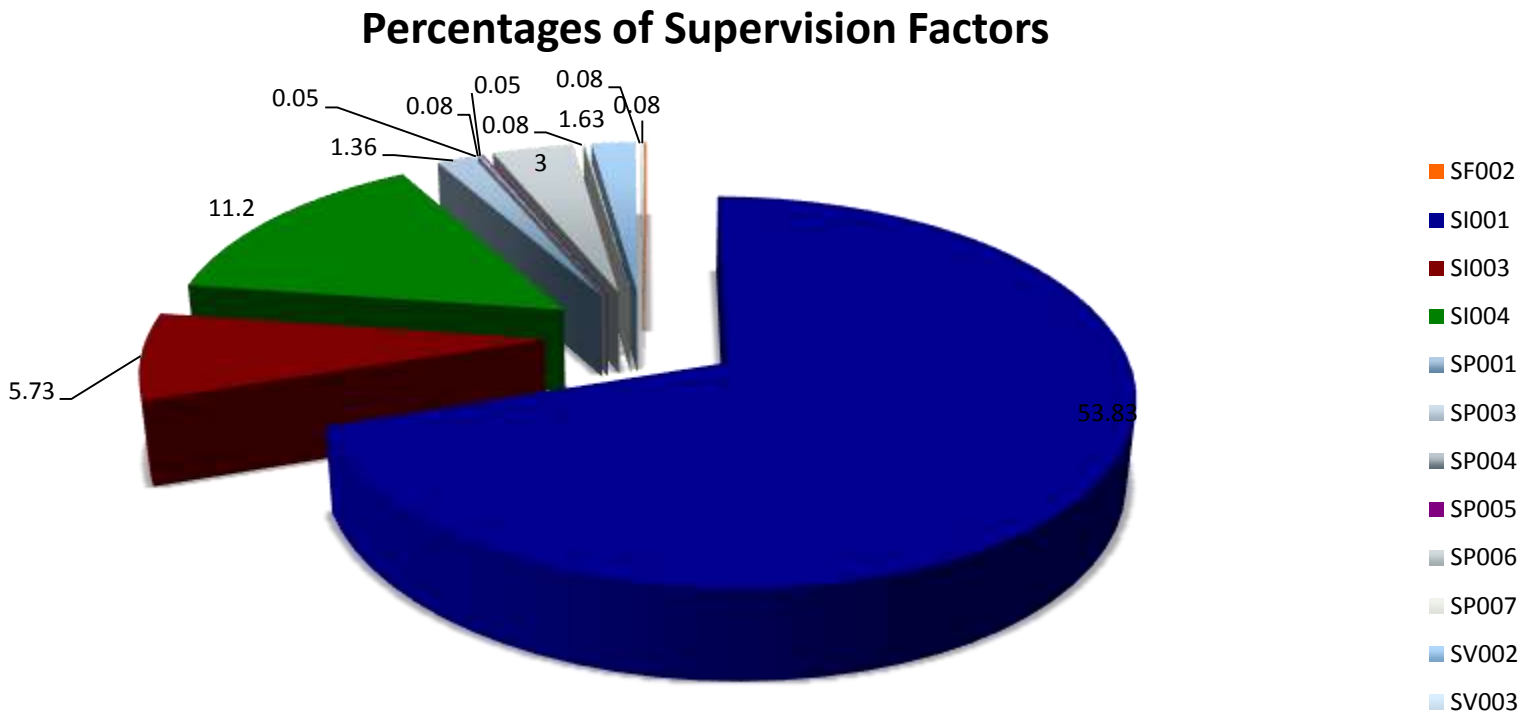
- **Channelized Attention**
  - Channelized Attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. Channelized Attention may be described as a tight focus of attention that leads to the exclusion of comprehensive situational information.

- **Pressing (Pressure)**
  - Pressing is a factor when the individual knowingly commits to a course of action that presses them and/or their equipment beyond reasonable limits.

- **Complacency**
  - Complacency is a factor when the individual's state of reduces conscious attention due to an attitude of overconfidence, under-motivation or the sense that others "have the situation under control" leads to an unsafe situation.

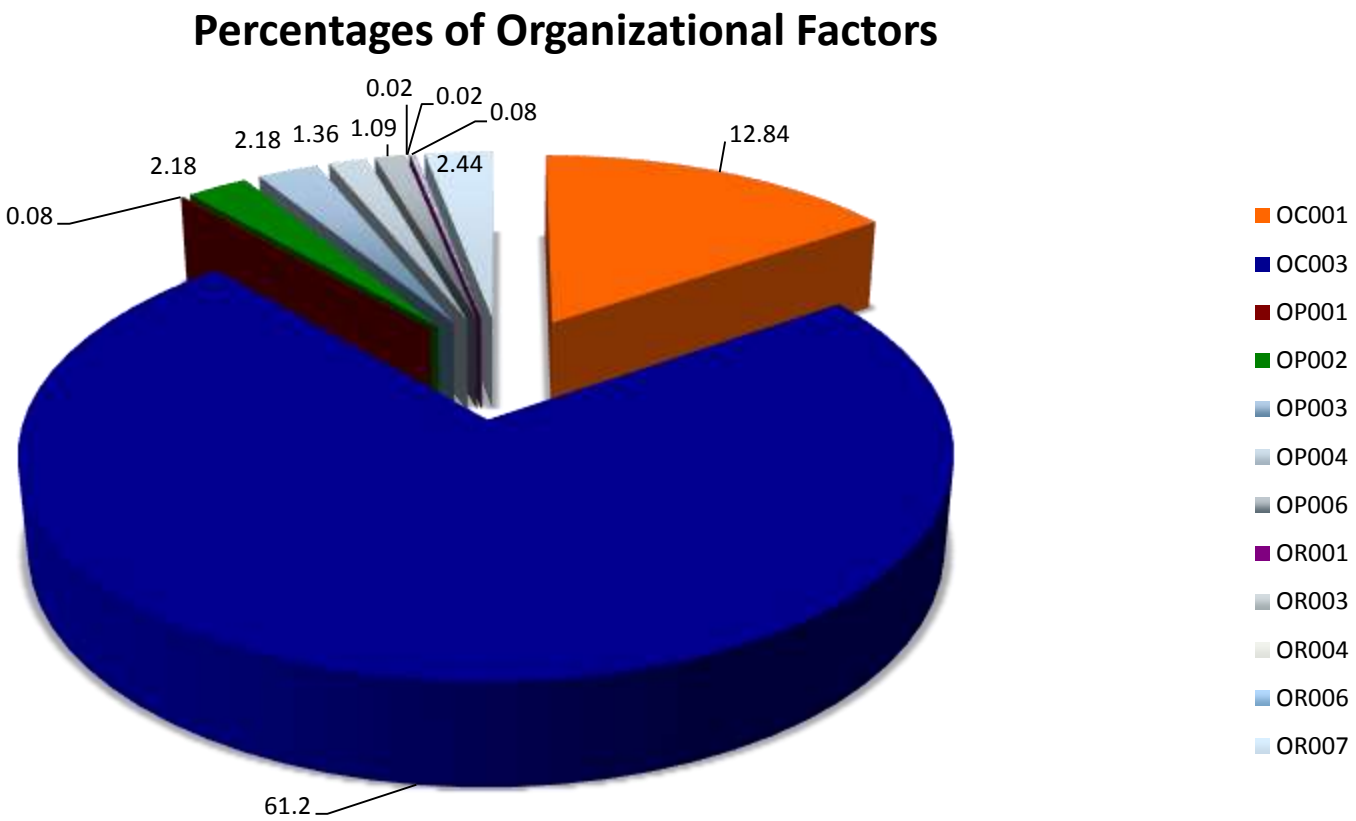
- **Mental/Physiological Fatigue**
  - Mental/Physiological Fatigue is a factor when the individual's diminished physical or mental capability is due to an inadequate recovery, as a result of restricted or shortened sleep or physical or mental activity during prolonged wakefulness. Mental/Physiological Fatigue may be described as acute, cumulative or chronic.

Supervision Factors



54% SI001 Leadership/Supervision Inadequate
11% SI004 Supervision Policy
6% SI003 Local Training Issues/Programs

Organizational Factors



61% OC003 Perception of Equipment
12% OC001Unit/Organization Values/Culture
3% OR008 Information Resources Support

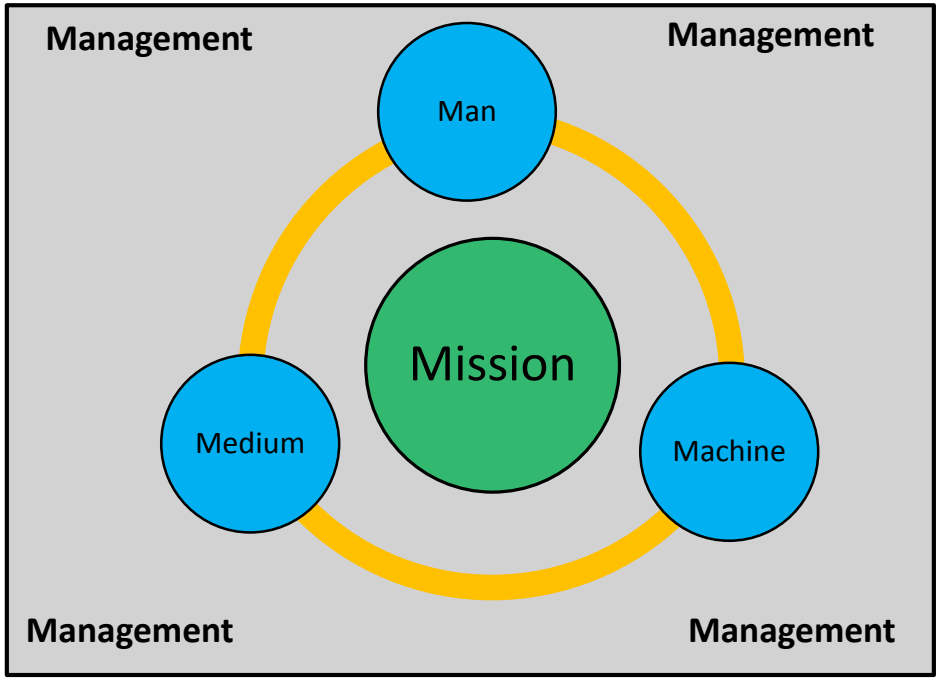
Negative Human Factors, the "Dirty Dozen"

- The "Dirty Dozen" are the most common reasons why people make the errors they don't intend to make.

- By being aware of these factors and properly mitigating them, nearly all human factor incidents can be avoided.

  - Lack of Communication
  - Complacency
  - Lack of Knowledge
  - Distraction
  - Lack of Team Work
  - Fatigue
  - Lack of Resources
  - Pressure
  - Lack of Assertiveness
  - Stress
  - Lack of Awareness
  - Norms

Operational Risk Management (ORM)



- **Insitu Operational Risk Management Process:**
  - **Step 1:** Identify hazard
  - **Step 2:** Assess the risk
  - **Step 3:** Analyze controls
  - **Step 4:** Decide on the best control
  - **Step 5:** Implement the control
  - **Step 6:** Supervise and review
- **Decision making process must:**
  - Accept no unnecessary risk
  - Make risk decisions at the appropriate level
  - Accept risk when benefits outweigh the costs
- **Other Considerations:**
  - Hold safety briefs prior to any hazardous operation; this sets the tone for the operation and helps cage individuals minds.
  - Cross-monitor performance: back check each other on safety of flight or personnel safety critical tasks.
  - Establish a code term such as “knock it off” to identify immediate safety concerns and trigger personnel to take the appropriate action.
  - Hold a safety hour routinely once a week to discuss operations and focus on personnel and flight safety.

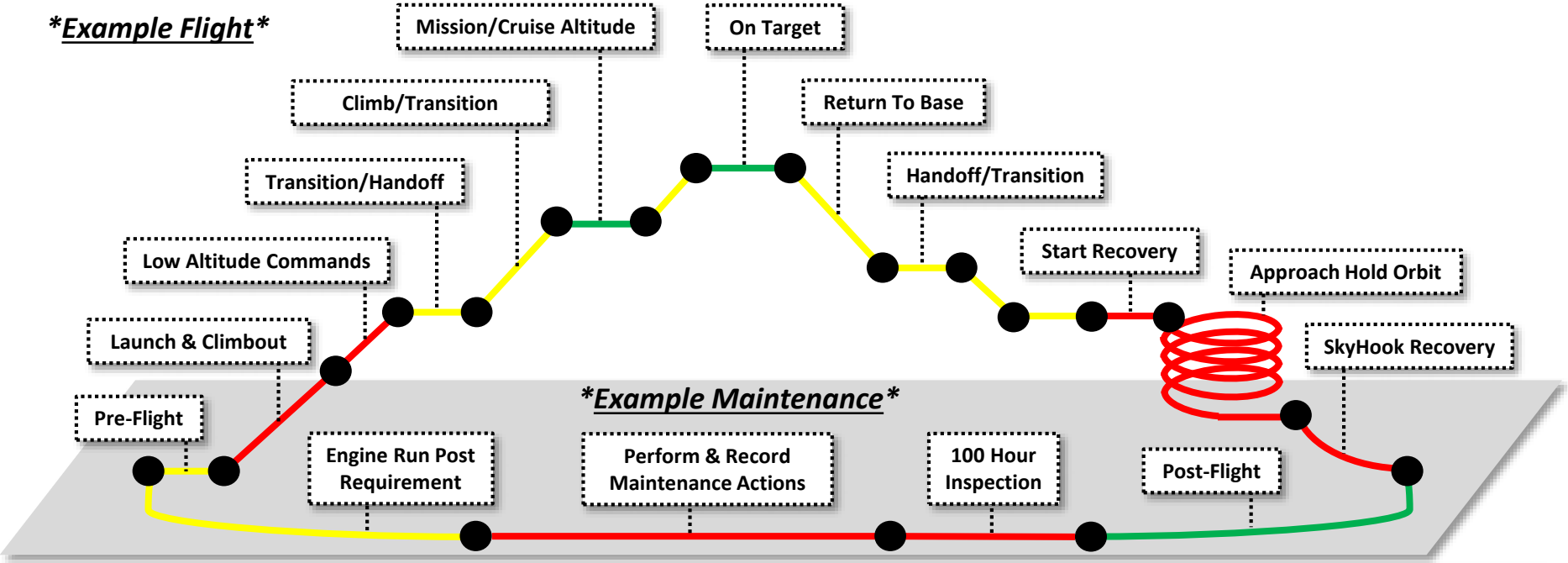
Human Factors Threat and Risk

- **Purpose and Scope:**
  - The Human Factors Threat Level matrix helps UAS personnel identify hazards and risks that are conducive to Human Factors within specific areas of UAS operations. The matrix categorizes the hazards and risks into: (1) In Flight and (2) On Ground/Maintenance. A threat level of either High, Medium, or Low is assigned to a particular phase of operation or action based upon the severity and/or number of risk factors. The matrix, seen in the figure below, is used in the following slide to depict the different threats and risks for various phases of operation and maintenance actions encountered during an *EXAMPLE* mission life-cycle.

- **Description:**
  - For any given phase of operation (i.e. pre-flight, climbout, recovery) and maintenance action, there are associated hazards and risks which influence the likelihood of a UAS person experiencing a human factor. For example, the threat of human factors may be increased to high, if a pilot performs a SkyHook Recovery at a remote, high density altitude site surrounded by mountainous terrain during summer months with low fuel because of the likelihood of increased pressure on the pilot leading to a procedural error. Likewise, the human factors threat may inherently increase when performing maintenance inspections due to the risk of limited availability of parts/equipment.

Human Factors Threat and Risk

Threat	In Flight Risks	On Ground/Maintenance Risks
High	All flight below 600' AGL, high workload, emergency situations, severe weather conditions	Harsh environment, emergency situations, high workload, insufficient crew rest periods, limited or no connectivity, time constraints, limited materials/tools
Medium	Changes in AP-status/aircraft configuration, hot/cold weather climbs and descents, high altitude operations, unstable weather conditions, congested airspace, medium workload	Engine running, carrying aircraft, removing aircraft from capture rope, medium workload, hot/cold weather ground operations, maintenance database not updated
Low	Simple, Stable, Safe Straight and level flight or in orbit at cruise/mission altitude, stable weather, low workload	Simple, Static, Safe Aircraft secured in cradle, Launcher/SkyHook setup, low workload, routine maintenance actions, good connectivity



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Case Study Guidance and Format

Guidance:

- Read through introductory summary, statements, and other factors.
- Develop a mental picture of the scenario through the sequence of events.
- Ask yourself what Human Factors were causal and/or contributory to the mishap.
- Assess the situation and determine your own Human Factors Threat and Risk.
- Group discussion of associated Human Factors and other safety of flight issues is highly encouraged.

Case Study - Introduction Slide:

- Date, IMUSE version, aircraft configuration, elevation, winds, and weather.
- Summary of mishap.
- Initial Findings and Evidence
- Human Factors Threat and Risk
- Reference Material:
  - Published Insitu Documentation (i.e. Handbooks, Service Bulletins)
  - Photos, video, and screen captures
  - Witness Statements

Case Study - Elements Slide:

- Findings
- Human Factors
- Mitigation Techniques

Case Study #: 1

Stuck Throttle – Procedural Error

Site: Land **Date: Jul-2014** **IMUSE Version: 5.8** **Payload: Standard EO**

Engine: Hush **Elev.: 4060' MSL** **Winds: 1-3 knots** **Temp.: 26C** **Sky/Weather: Clear**

Summary:

"During pre-flight the aircraft did not exhibit any abnormal conditions and was loaded on the launcher. The engine pre-flight was also conducted with no abnormal indications and the aircraft was commanded for launch. Aircraft operated with no abnormal responses during launch, climbout, and initial level off. Shortly after leveling off, the aircraft began to descend slightly below the commanded altitude of 8000' MSL. The throttle responded by gradually increasing the commanded throttle position however no response was observed in RPM and an "Engine Power Low" alarm was noted by the pilot. The pilot was informed to run the stuck throttle emergency procedure; however, this and other troubleshooting did not resolve the condition. The engine RPM was insufficient to maintain altitude and the aircraft was setup for belly landing. The aircraft was recovered following the mishap and was repaired and returned to service."

Initial Findings:

- Post-mishap photographs indicated the throttle linkage was disconnected at the carburetor.
- SB200-08-038 Throttle Linkage Screw Threadlocker issued on 16-Dec-2013.
- No Maintenance Action Form found that ensured the service bulletin had been complied with.
- Torque paint was not applied to the throttle servo screw and arm.

Click on objects below

Human Factors Threat and Risk

Threat	On Ground Risks
Medium	Maintenance data was not available in the computerized maintenance management system (Sapphire). Lack of electronic awareness of required maintenance actions.

- **Findings:**
  - Post-mishap photographs showed that the throttle linkage was disconnected at the carburetor.
  - Historical throttle linkage disconnects had been the result of a lack of threadlock application to the throttle linkage to carburetor screw.
  - SB200-08-038 ScanEagle – Throttle Linkage Screw Threadlocker was issued on 16-Dec-2013. This date was after the engine had been installed on the aircraft and was also after the aircraft had been flown at the previous site.
  - The aircraft location and status was unknown at the time of the issuance of the service bulletin; however, after the service bulletin was released there was no documentation in the form of a maintenance action form found that ensured the service bulletin had been complied with.
  - According to the service bulletin procedure, the visual indication on the throttle linkage and servo assembly should have included torque paint. Torque paint was not applied to the throttle servo screw and arm as instructed by the service bulletin.
  - The service bulletin addressed that, if the service bulletin was complied with but no torque paint was available, then prior to each flight the maintenance action form should be referenced to ensure that the service bulletin was complied with for that specific engine.
  - Maintenance data was not available in the computerized maintenance management system (Sapphire) for the aircraft between the period when the service bulletin was issued and when the mishap event occurred. This lack of maintenance data available created another opportunity for the site to fail to identify that the service bulletin had not been completed. Use of the system should have highlighted that the service bulletin was not complied with and that the aircraft was should not have been flown without having the service bulletin completed.

- **Human Factors:**
  - Error due to Misperception: Maintenance personnel perceived the aircraft was an airworthy aircraft upon receipt from the previous site and failed to ensure that all service bulletins and required maintenance had been complied with.
  - Inattention: Maintenance personnel did not provide adequate attention to ensure that aircraft was in compliance with all required service bulletins and maintenance actions.

- **Mitigation Techniques:**
  - Maintain currency and proficiency with all Service Bulletins and Advisories.
  - Ensure compliance with service bulletins and advisories.
  - Have a Status Sheet that shows completed, open, upcoming/scheduled, and recurring maintenance actions.

Case Study #: 2

Rate Sensor Failure – Checklist Error

Site: Maritime **Date: Jan-2014** **IMUSE Version: 5.5** **Payload: Standard EO**

Engine: Hush **Elev.: 0' MSL** **Winds: 20 knots** **Temp.: 28C** **Sky/Weather: Clear**

Summary:

"No abnormalities were noted by site personnel during pre-flight, launch, and initial climbout. The surface winds were 200° at 20 knots, and resulted in the aircraft being launched with a south easterly heading from the ship. At approximately 150' AGL and nearly 9 seconds after launch, the ground crew noticed an aggressive roll to the right, followed by a hard over correction to the left, and then a nose dive into the ocean. The aircraft flew for approximately 13 seconds before impacting the water at a high rate of speed. The aircraft was not recovered."

Click on objects below

Initial Findings:

- Review of telemetry indicated two sets of pitch, roll, and yaw rate pre-flight checks. During both checks, the roll rate sensor did not respond to a roll effect on the aircraft, if a roll effect to the aircraft was performed.
- The erroneous roll rate indications on the Flight Control plot strongly suggested a malfunctioned roll rate sensor, which led to the un-commanded descent into the water.

Human Factors Threat and Risk

Threat	On Ground Risks
Medium	Performing critical pre-flight IMUSE checklist items.

- **Findings:**
  - Review of telemetry indicated two sets of pitch, roll, and yaw rate pre-flight checks. During both checks, the roll rate sensor did not respond to a roll effect on the aircraft, if a roll effect to the aircraft was performed. During the process of moving the aircraft from the pre-flight location to the launcher, the pitch and yaw rate sensors indicated changes; however, the roll rate sensor did not indicate any change.
  - A comparative analysis between the ship's Attitude Heading and Reference System (AHRS) pitch and roll rates to the aircraft's pitch and roll rates also confirmed the erroneous aircraft's roll rate indication.
  - The erroneous roll rate indications on the Flight Control plot strongly suggested a malfunctioned roll rate sensor, which led to the un-commanded descent into the water.

- **Human Factors:**
  - Checklist Error: Pilot did not adequately identify the presence of a faulty rate sensor when following established procedures to identify equipment performance parameters prior to launching aircraft.
  - Challenge and Reply – Pilot and air crew did not provide adequate communication on rate sensor checks during pre-flight.
  - Complacency – Pilot's state of reduced conciseness resulted in failure to identify failed roll rate sensor.

- **Mitigation Techniques:**
  - Ensure appropriate attention to detail during execution of pre-flight checklist items.
  - Ensure use of challenge and reply process between pilot and ground crew during critical pre-flight checklist items.

Case Study #: 3

HAZREP 057 Near Mid-Air Collision – Communication

Site: Land **Date: Aug-2015** **IMUSE Version: 5.7** **Payload: Standard EO**

Engine: HFE **Elev.: 0' MSL** **Winds: 16 knot** **Temp.: 28C** **Sky/Weather: Scattered**

Summary:At approximately 1900L Scan Eagle UAS was cleared by tower to initiate an approach, heading 030 degrees. The 030 degree approach requires us to begin the descent from the west side of the runway, then crossing the active in order to safely recover on the east side of the field. After being cleared multiple times for attempted recoveries with no success, a call was made from tower to hold to the west side of the runway, giving way to manned Italian rotorcraft approaching from the south. At that time the ground crew positively identified the incoming aircraft and instructed our operator to push to the west for de confliction purposes. We understood the distance between the manned and unmanned aircrafts were within a proximity to where all parties involved were alarmed, but at no point was our aircraft at a distance in which our ground crew was confident of a mid air occurrence.

Initial Findings:

- Maintenance was being done on GCS so MC was in a separate connex with remote communications to ATC and PIC.
- Pilot was being trained by field trainer who was not aware of the conflicting traffic proximity.

Click on objects below

Human Factors Threat and Risk	
Threat	**In Flight Risks**
High	**Multiple factors lead to a breakdown in communication between ATC, Mission Commander, Pilot in Command and helicopter 2-ship**

Human Factor Findings

- **Findings:**

FM0D4- Situation Awareness

There was a lack of situation awareness from the PIC during the near miss incident. Even though this was the pilot's first flight in field, there wasn't complete awareness to the surrounding factors of the situation at hand. The PIC and FT had a lack of urgency in regards to the communicated incoming airfield traffic.

FMOG2- Cross-Monitoring Performance

Cross-Monitoring performance is the state of efficiency in which a team can effectively communicate each other's status, and attribute any help other team members may need. During this mission, the crew communication was disorderly and did not allow a deliverable safe situation. This mostly attributes to the lack of preventative measures that could have taken place, if the PIC's status was monitored by all the crew. In addition, the MC was the only crew member in communication with tower, and did not sufficiently relay the urgent information to make sure they were cleared of the airfield.

FMOG0- Crew Group Communication Inadequate

Crew Group Communication is the communication dynamic shown by the crew, and their ability to sustain proper connectivity. Due to the network being down, the MC was unable to determine the placement, and the crew was lost through the multiple networks of communication. The communication was cluttered, and needed an overall standard terminology. Having this would have prevented the lack of urgency between PIC, FT, GC, and MC.

FM0I0- Inadequate Oversight

Oversight by a superior crew member encompasses providing appropriate guidance, allowing availability, having competency of mission, and providing other important aspects to create a mission safe environment. The FT, who was watching over the PIC, disregarded the call to cancel approach, and failed to indicate to the inexperienced PIC where the runway centerline was.

FM0I1- Local Training Issues

Training issues fall under the local site, the patterns, and specific set up that was being used. This is an especially important aspect when pertaining to an inexperienced PIC. In this scenario, as taken from the witness statements, the PIC was not properly trained to decipher the runway centerline on IMUSE, leading to the unsafe mission environment.

Recommendations

➢ **Human Factors and Mitigation Techniques:**

Human Factors recommendations will be given based on the Flight Safety Failure Modes assigned to the near miss. The recommendations are broken down and stated at the end of the Failure Mode classifications. There are four major areas which need improvement: operator awareness, crew communication, oversight, and training.

Communication Recommendation

Noticeably crew communication and cross monitoring was an issue in this near miss scenario, contributing to the numerous errors. To allow communication to improve, a follow through protocol should be set in place for each crew member contributing specific feedback information during the mission. This protocol would reduce the clutter of reiteration of messages and allow one members input to be noticed and acted upon. In addition, each crew member should have accountability for the warnings input given, this attributes to the cross-monitoring dynamic of the crew. If a warning or cautionary message is given, follow through to ensure the crew member received the message is appropriate. Report 6 of 7 PR101212

This leads into the importance of standard communication. Having common phrases and terminologies between crew members reduces the possibility of confusion and miscommunication during periods of high stress. Establishment of these crew dynamics should be developed in a debrief to ensure efficient communication and readiness for each mission.

Oversight

There should be site specific credentials for a FT/PIC duo. These credentials should be based on experience levels, site complexities, and site experience. If there is a standard already set in place, there should be a protocol for FT/PIC to debrief prior to mission. This would ensure the vital efficient communication needed.

Local Training

The local training pertains to the importance of site pass down, and the proper instruction in regards to the knowledge of site differences. Due to variation of each site operation, this is a very important aspect to mission completion.

Thank You.

Any questions?

Flight Safety

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