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ASTM International Committee F38 on Unmanned Aircraft Systems

ASTM Meeting at AUVSI, Dallas, TX

8 May 2017

Ted Wierzbanowski
Chair, ASTM International Committee F38

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Agenda - Overview

- Welcome and Standards Overview (W+12)
- F54.09 Update (Adam Jacoff)
- FAA Update (Wes Ryan et al)
- Main Committee Opening (W+12/M+11)
- Sub Committee Reports
  - F38.01 Airworthiness (Ajay Sehgal)
- Lunch (on your own – several options)
  - F38.01 Airworthiness (Cont - Ajay Sehgal)
  - F38.02 Operations (Mark Blanks)
  - F38.03 Personnel (W+12)
- Main Committee Closing (W+12/M+11)

Agenda – Details (*note: times are flexible*)

Sign in
F38 Welcome and Standards Overview - Ted Wierzbanowski
E54.09 Status Update - Adam Jacoff
FAA UAS Overview and NOA update and discussion – Wes Ryan et al
F38 Main Committee Opening
BREAK
F38.01 Airworthiness Subcommittee
sUAS Operations Over People (WK52089) - discuss recent ballot and answer questions
Micro UAS Operations over People (WK56338) - status update
Extended/Beyond Visual Line of Sight (F3196) - discuss proposal to add attachment for EVLOS and reference to Canadian BVLOS Best Practice document. Short briefing on Pathfinder #2 final results.
LUNCH
F38.01 Airworthiness Subcommittee (cont)
Trustworthy Autonomy using Run Time Assurance (RTA) Approach
Safely Bounding Complex Algorithms (WK53403) - discuss recent ballot and resolve any negatives
Design, Construct, and Test (F2910-14) - status update
Design, Construction, and Verification of Fixed Wing (WK52962) - status update
Design, Construction, and Verification of VTOL (WK53964) - status update
Design of Command and Control System (F3002) - discuss recent ballot and resolve any negatives
Use of Batteries (F3005) - discuss recent ballot and resolve any negatives
Software Dependability (F3201) - status update
Production Acceptance (F2911-14e1) - status update
Quality Assurance (F3003-14) - status update
BREAK
F38.03 Personnel Training, Qualification, and Certfication Subcommittee
Pilot/Visual Observer Training (WK29229) - discuss recent ballot and resolve any negatives
Aircraft Flight Manual (F2908-16) - status update
F38.02 Flight Operations Subcommittee
Maintenance and Continued Airworthiness (F2909-14) - status update and discussion of issues
Operational Risk Assessment (F3178) - status update
F38 Main Committee Closing

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ASTM International Committee F38 on Unmanned Aircraft Systems

Status Update

8 May 2017

Ted Wierzbanowski*
Chairman
ASTM International Committee F38
www.astm.org

* This material represents the views and positions of the presenter and not those of ASTM International and/or the entire ASTM F38 Committee

ASTM International Committee F38 Topics

- Vision, Mission, & Structure
- Focus on small UAS (sUAS/sRPAS)
  - Background
  - Published standards
  - Other sUAS standards in development
- Global Acceptance of sUAS Standards
- Conclusion

ASTM International Committee F38

Vision

– Routine, safe UAS operations in civil airspace through standardization.

Mission

– Produce practical, consensus standards that facilitate UAS operations at an acceptable level of safety. These standards include the design, manufacture, maintenance and operation of unmanned aircraft systems as well as the training and qualification of personnel. Committee F38 supports industry, academia, government organizations and regulatory authorities.

ASTM International Committee F38

Structure

- F38.01 Airworthiness (Ajay Sehgal)
  - Product (hardware/software) oriented
  - Safe design, construction, test, modification, & inspection of the individual component, aircraft, or system
- F38.02 Operations (Mark Blanks)
  - Procedure/performance oriented
  - Safe employment of the system within the aviation environment among other aircraft & systems
- F38.03 Personnel (Scott Strimple)
  - Crew oriented
  - Safe practices by the individuals responsible for employing the system

Focus on small UAS (sUAS/sRPAS)

Background

- ASTM F38 UAS Standards Committee formed in 2003
- Efforts on developing standards for small UAS with FAA support
  - Began in 2010
  - Are being accelerated to support other than Part 107 operations
- Many standards have been published
- More standards are being developed and finalized

Continued participation in ASTM UAS standards development by sUAS stakeholders is highly encouraged

Focus on small UAS (sUAS/sRPAS)

Published sUAS Standards

- Design, construction, and test (F2910) - being replaced (see next chart)
  - Design of the C2 subsystem (F3002) - revision being finalized
  - Use of batteries (F3005) - revision being finalized
- Production acceptance (F2911) - available
- Quality assurance (F3003) - available
- Maintenance and continued airworthiness (F2009) – revision in work
- Aircraft flight manual (F2908) - available
- Ensuring Software Dependability (F3201) - available
- Operational Risk Assessments (F3178) – available
- Extended/Beyond Visual Line of Sight Operations (F3196) – available

Work continues to improve these standards and develop new ones shown on the following chart

Focus on small UAS (sUAS/sRPAS)

Other sUAS Standards in Development

- sUAS Operations over People (WK52089) - in ballot
- Safely Bounding Flight Behavior of UAS Containing Complex Functions (WK53403) – comments on previous ballot being adjudicated
- Training of Pilots and Visual Observers (WK29229) - in ballot
- Design, Construct, and Validation
  - Fixed wing (WK52962) - draft in work
  - VTOL (WK53964) - draft in work
- Micro UAS Operations over People (WK56338) – draft in work

Continued participation in ASTM UAS standards development by sUAS stakeholders is highly encouraged

ASTM International Committee F38

Global Acceptance of sUAS Standards

- ASTM is a recognized international standards development organization
  - 180+ members on F38
  - 15 nations represented on F38
- Global acceptance of ASTM sUAS standards is in best interest of the sUAS/sRPAS community
  - Benefit to builders: Lowers manufacturing costs/avoids multiple versions
  - Benefit to buyers: Lowers acquisitions costs
- ASTM is seeking more active participation from the global sUAS/sRPAS stakeholder community
  - Reduce duplication of standards development efforts
  - Maximize effectiveness/efficiency of limited “volunteer” resources

Conclusions

- Consensus standards will be key enabler for:
  - sUAS “special class” certification
  - Waivers to Part 107 sUAS operations
  - Other sUAS operational approval efforts “worldwide”

- Significant progress has been made in the development of these standards but lots of work ahead

- The FAA is supporting continued efforts to improve published standards and develop new ones

YOUR ACTIVE PARTICIPATION AND SUPPORT IS ALSO NEEDED!!

ASTM International Committee F38

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F54.09 Update

ASTM Meeting at AUVSI

8 May 2017

Adam Jacoff
Chair, ASTM International Subcommittee E54.09

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Questions/Discussion

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FAA Update

ASTM Meeting at AUVSI

8 May 2017
Wes Ryan

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Questions/Discussion

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Main Committee Opening

ASTM Meeting at AUVSI

8 May 2017

Ted Wierzbanowski (W+12) - Chair, ASTM International Committee F38
Mary Mikolajewski (M+11) – Staff Manager, ASTM International Committee F38

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Agenda – F38 Main Committee Opening

- **Call to order** (W+12)
- **Approval of the agenda** *(Action: motion, second, vote)*
- Normal formal meeting processes (M+11)
- Approval of previous meeting minutes (W+12)
- Membership report
- Old business
- New business
- Recess

F38 Main Committee Opening (cont)

- **Normal formal meeting processes** (M+11)
- **Approval of previous meeting minutes** (W+12) *(Action: motion, second, vote)*

F38 Main Committee Opening (cont)

– Membership report

Balance Report
As of 5/4/2017 4:27 PM

Producer Votes Available: 4

	Producer	User	Consumer	General Interest	Unclassified	Total
Official Voting Member	56	10	0	50	0	116
Non Official Voting Member	16	4	0	41	1	62
TOTAL	72	14	0	91	1	178

F38 Main Committee Opening (cont)

Old business

Standard terminology for UAS

New business

New sub committee on ground systems (drone ports, GBSAA, etc)

Elections – Nominating committee results:

- Chairman – Phil Kenul
- Vice Chairman – Ajay Sehgal
- Recording Secretary – Kirk Kloeppel
- Membership Secretary – Jonathan Daniels

- Nominations from the floor?

Recess

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F38.01 *Airworthiness Subcommittee*

ASTM Meeting at AUVSI 2017

8 May 2016

Ajay Sehgal
Chair, ASTM International Subcommittee F38.01
(Chief Engineer, KBRwyle Aerospace Group, Lexington Park, MD)

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F38.01 Agenda

- **Call to order** (Sehgal)
- **Approval of agenda** *(Action: motion, second, vote)*
- Membership report (Sehgal)
- Standards overview (Sehgal)
- Task group reports (TG Chairs)
- New business
  - What's next? (Sehgal)
  - Items from the floor?
- Summary action items (Sehgal)
- Adjournment

F38.01 Standards Overview

10:15 - 12:00	Committee Membership / Standards Overview	Sehgal	10 min
	sUAS Operations Over People (WK52089) - discuss recent ballot and answer questions	Marshall	25 min
	Micro UAS Operations over People (WK56338) - status update	Stockwell	25min
	Extended/Beyond Visual Line of Sight (F3196) - discuss proposal to add attachment for EVLOS and reference to Canadian BVLOS Best Practice document. Short briefing on Pathfinder #2 final results	W+12	30 min
12:00 - 1:00	***LUNCH***		
1:00 - 3:00	Trustworthy Autonomy using Run Time Assurance (RTA) Approach	Skoog	30 min
	Safely Bounding Complex Algorithms (WK53403) - discuss recent ballot and resolve any negatives	Cook	20 min
	Design, Construct, and Test (F2910-14) - status update	W+12	5 min
	Design, Construction, and Verification of Fixed Wing (WK52962) - status update	Daniels	20 min
	Design, Construction, and Verification of VTOL (WK53964) - status update	Sehgal	5 min
	Design of Command and Control System (F3002) - discuss recent ballot and resolve any negatives	Stockwell	10 min
	Use of Batteries (F3005) - discuss recent ballot and resolve any negatives	Somandepalli	10 min
	Software Dependability (F3201) - status update	Cook	5 min
	Production Acceptance (F2911-14e1) - status update	W+12	5 min
	Quality Assurance (F3003-14) - status update	W+12	5 min
	New Business / Closing / Actions	Sehgal	5 min

F38.01 Membership Report

Balance Report
As of 05/02/2017

Producer Votes Available: 37

	Producer	User	Consumer	General Interest	Unclassified	Total
Official Voting Member	25	10	1	51	0	87
Non Official Voting Member	2	4	0	17	2	25
Total	27	14	1	68	2	112

F38.01 Standards Overview

APPROVED

• F2910-14	Design, Construct and Test (to be replaced by separate Fixed Wing and Rotary Wing)	W+12
• F2911-14e1	Production Acceptance	W+12
• F3002-14a	Design of Command and Control System	Stockwell
• F3003-14	Quality Assurance	W+12
• F3005-14a	Use of Batteries	Somandepalli
• F3201-16	Ensuring Dependability of Software	Cook
• F3196-17	Extended/Beyond Visual LOS Operations	W+12

DRAFT

• WK52089	sUAS Operations Over People	Marshall
• WK52962	Design, Construction and Verification- Fixed Wing	Daniels
• WK53964	Design, Construction and Verification- Rotary Wing	Strimple
• WK53403	Safely Bounding Complex Functions	Cook
• WK56338	Micro UAS Operations Over People	Stockwell

Operations Over People of Small Unmanned Aircraft System (sUAS)

Designation: **WK52089**

Last Balloted: 5 May 2017

Status: See next chart(s)

Summary:

This practice is intended to define the process and recommended practices to be followed by a proponent to obtain approval from a CAA to operate an sUAS over people. The practice requires a risk-based approach to obtaining this approval, as well as identifying specific potential risks and risk mitigation strategies a proponent could propose to an CAA. The practice is not intended to be prescriptive, but instead to recommend the processes necessary to comply with the applicable ASTM standards.

TG Lead:

Doug Marshall	TrueNorth Consulting

TG Members:

Brian Argrow	CU Boulder
Rich Hanson	AMA
Andy Johnson-Laird	Johnson-Laird, Inc.
Scott Strimple	CinemAerial

Operations Over People

Status

- Ballot released 5 May 2017
  - Hybrid standard (process and specifics)
  - Performance-based requirements include:
    - System definition
    - CONOPS
    - Operational Risk Assessment (separate standard)
    - Proposed risk mitigations (some potential ones identified)
    - Refinement until joint determination that risks are acceptable
- Ballot closes 5 June 2017
- Large volume of comments received for first two drafts
- It has taken several months of regular meetings to resolve comments
- The new draft has been harmonized with BVLOS/EVLOS in content

Operations Over People

Background and History

- January 2014: FAA anticipating a small UAS rule derived from sUAS Aviation Rulemaking Committee recommendations. FAA sees need for a standardized approach.
- The initial effort began under another WK number in mid-2013, and experienced months of frustration from conflicting feedback from the sponsor.
- WK52089 formed in March 2014 under ASTM F38
- Most recent effort (with the first of 3 ASTM/FAA-generated TORs) began June 2014
- Motivation: New Part 107 rule does not permit flights over people. Operations over people are high priority for commercial operators (news gathering, inspections, advertising, etc.). High demand from the commercial community for this type of operation.
- Approach: To recommend a practice and process that CAAs will be able to approve with an assessment of minimal risk of severe injury to non-participants.
- Leverage: Commercial operators and OEMs already developing systems and procedures to augment OOP and convince the general public that it can be done safely.

WK52089 Practice For Seeking Approval for Operations Over People of Small Unmanned Aircraft System (sUAS)

Operations Over People

Ballot Response

- Standard balloted to F38.01 (January 2017)
- 72 Total Comments
  - 7 Negative
  - 37 Substantive
  - 16 Editorial

Affirmative	48
Negative	7
Abstain	17
%Affirm	88.09

- All comments have been adjudicated and significant changes made to the third version of standard

- Ballot on this version closes on 5 June 2017

Thank you to F38.01 for the constructive comments!

Operations Over People

Some Observations on WK52089 Version 3

- Harmonized structure, terminology, and some content with the BVLOS/EVLOS standard.
  - The content is more “readable” and flows in a fashion similar to the BVLOS/EVLOS standard.
- Deleted most of references to Digital Flight Data Recorders and referenced instead digital flight parameter recorders that are already found on most commercial and professional grade sUAS. In addition, any standard for DFDRs will be developed in another ASTM subcommittee or task group.
- Eliminated some terminology and concepts that elicited many negative comments in the first two ballots.
  - Notwithstanding continuing efforts to make the standard as user friendly as possible, many of the negative comments seem to reflect or demonstrate a lack of understanding of what a Standard Practice is intended to accomplish. While we tried to avoid language that could be interpreted as imposing requirements, rather than practices, some commenters still read the recommendations as requirements and demonstrated a singular lack of awareness of the technology already available on consumer sUAS.
  - This version is a further attempt to clarify the intent and to alleviate the concerns of those that interpret these recommendations as imposing new, or burdensome requirements.
  - An underlying concept that reflects the FAA’s philosophy is that unmanned systems intended for flight over non-participants probably should be more reliable and incorporate more design and operational mitigations so as to minimize the risk of harm to others than if the aircraft were to be flown over a remote or unpopulated area.
- Lesson learned: It is not a cost-effective use of volunteer task groups members’ time to commence the development of a standard before a TOR is agreed to by responsible entities.

Operations Over People

Way Forward

- Third version of WK52089 in ballot, incorporating feedback from first two ballots

- If no negatives received, standard can be published after editorial comments are incorporated. If not, will need to address negatives.

- This may be the first community-based standard to support CAA approval of operations of small UAS over people

Micro UAS Operations Over People

(Standard Test Method for Safety)

Overview

Designation: **WK56338**

Last Balloted: New

Status: See next chart

Summary:

Develop a test method or methods to quantify the safety of sUAS flying over people. Test methods will include estimates of potential injury from impact and may also include laceration.

This should be a direct response to the expected NPRM based on the recommendations of the 2016 Micro ARC report. This standard may be useful in supporting Part 107.39 waiver applications.

TG Lead:

Walter Stockwell	DJI Research, LLC

TG Members (and other contributors):

Dave Arterburn	ASSURE, UAH
Michelle Tsai	GoPro
Adam Jacoff	NIST
Kamel Saidi	NIST
Raymond Sheh	Curtin University
Rich Hanson	AMA
Paul Albuquerque	FAA
Doug Marshall	ASTM
Ted W.	ASTM

Micro UAS Operations Over People

Status

- Slow start because the NPRM was put on hold… would this actually be needed?
- After internal discussion, decided that yes, this could be an interesting standard.
- In particular, the FAA has received >300 waiver requests for 107.39 (flying over people) and only granted 1.
- Currently focused on test methods:
  - Drop test that would measure impact on a head
  - Drop test onto a clay witness block
- Add correlation of measurements to predicted injury levels in appendix

Micro UAS Operations Over People

Status 2

- ASSURE has just released a big report on ground strike
  - We can use work in this report to get a first test method design
  - Takes advantage of existing FMVSS protocols, testing, data
- NIST has work on drop testing onto clay witness blocks
  - Potentially takes advantage of existing work on body armor and “less-lethal” ammunition
- ASSURE also has some work on laceration test methods and design mitigation

Micro UAS Operations Over People

Status 3

- This work may lead to creation of a family of interlocking standards:
  - Process for application for approval
  - Impact test method(s)
  - Design standard for laceration mitigations
  - Marking standard

- Work is progressing … but because of slow start we expect initial version in Q4 2017.

Extended/Beyond Visual Line of Sight

Overview

Designation: **F3196**

Approved: March 2017

Status: See next chart

Summary:

This practice defines the process to be followed to obtain approval from a NAA to operate a sUAS to fly at extended visual line of sight (EVLOS) or beyond visual line of sight (BVLOS) or both. It requires a risk based approach to obtaining this approval as well as specific potential risk mitigation strategies a proponent could propose to a NAA.

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TG Lead:

Ted Wierzbanowski

TG Members:

Jon Daniels	Praxis
Sean Cassidy	Amazon
Doug Marshall	TrueNorth
Buck Joslin	FAA
Nicolas Flom	ND Test Site
Andy Johnson-Laird	Johnson-Laird, Inc.
Thomas Rambo	Altavian
Andy Thurling	AeroVironment

Extended/Beyond Visual Line of Sight

Status

- Standard practice published in March 2017
  - Hybrid standard (process and specifics)
  - Requirements include:
    - System definition
    - CONOPS
    - Operational risk assessment (separate standard)
    - Proposed risk mitigations (some potential ones identified)
    - Refinement until joint determination that risks are acceptable
- Considering developing and balloting a proposed revision
  - Reference to Unmanned Systems Canada “Best Practices for BVLOS Operations”
  - Reference to new appendix for EVLOS best practices incorporating Pathfinder 2 results (next briefing)

Pathfinder # 2

Status

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LUNCH

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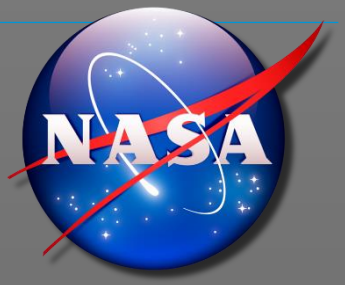


Trustworthy Autonomy Development & Flight Demonstration

Multi-Monitor Run Time Assurance Research Update

Mark Skoog
Armstrong Flight Research Center

Safely Bounding Complex Functions

Overview

Designation: **WK53403**

Last Balloted: 13 Jan 2017

Status: See next chart(s)

Summary:

The standard intends to develop a standard practice to safely bound the flight behavior of unmanned aircraft systems (UAS) containing complex functions, sometimes referred to as “autonomous”, “non-deterministic”, ”adaptive”, “intelligent”, and similar terms. Complex functions may cause the UAS to fly in a manner that is difficult to predict due to compounded implications from factors such as sensor measurement precision, environmental variables, resource availability, and aircraft system state. Verification of these algorithms may be too challenging to use conventional software approval methods.

TG Lead:

Steve Cook	Northrop Grumman

TG Members:

Robert Champagne	Amazon Prime Air
Anna Dietrich	Terrafugia
Eric Dunn	AeroVironment
Ken Fugate	FAA
Mike Garland	NASA
Loyd Hook	University of Tulsa
Dave Jenson	FAA
Andy Lacher	MITRE
Ife Ogunleye	FAA
Wes Ryan	FAA
Ajay Sehgal	KBRWyle
Mark Skoog	NASA
Thanh Trang	FAA
Andrew Thurling	AeroVironment
John Vanhoudt	FAA
Mike Vukas	FAA
Corrine Yu	Amazon Prime Air

Background and Motivation

- November 2015: FAA – NASA – AFRL – MITRE Workshop on Certifying Non-Deterministic Systems
  - Need for a standardized approach
- WK53403 formed in March 2016 under ASTM F38
- Motivation: Several UAS manufacturers desire highly automated, complex functionality
  - "It is widely recognized that existing certification criteria and processes do not properly account for the unique characteristics of adaptive, intelligent methods." - NASA/CR–2015-218702
  - Potential applications to improve safety of General Aviation
- Approach: For UAS, explore certifying a Run-Time Assurance Architecture around a *non-pedigreed* complex function to bound flight behavior
- Leverage ~20 years of research on run-time assurance, including current efforts at NASA and Air Force Research Laboratories

WK53403 ASTM Standard Practice for Methods to Safely Bound Flight Behavior of Unmanned Aircraft Systems Containing Complex Functions

Ballot Response

- Standard balloted to F38.01 (January 2017)
- 116 Total Comments
  - 8 Negative
  - 82 Substantive
  - 26 Editorial

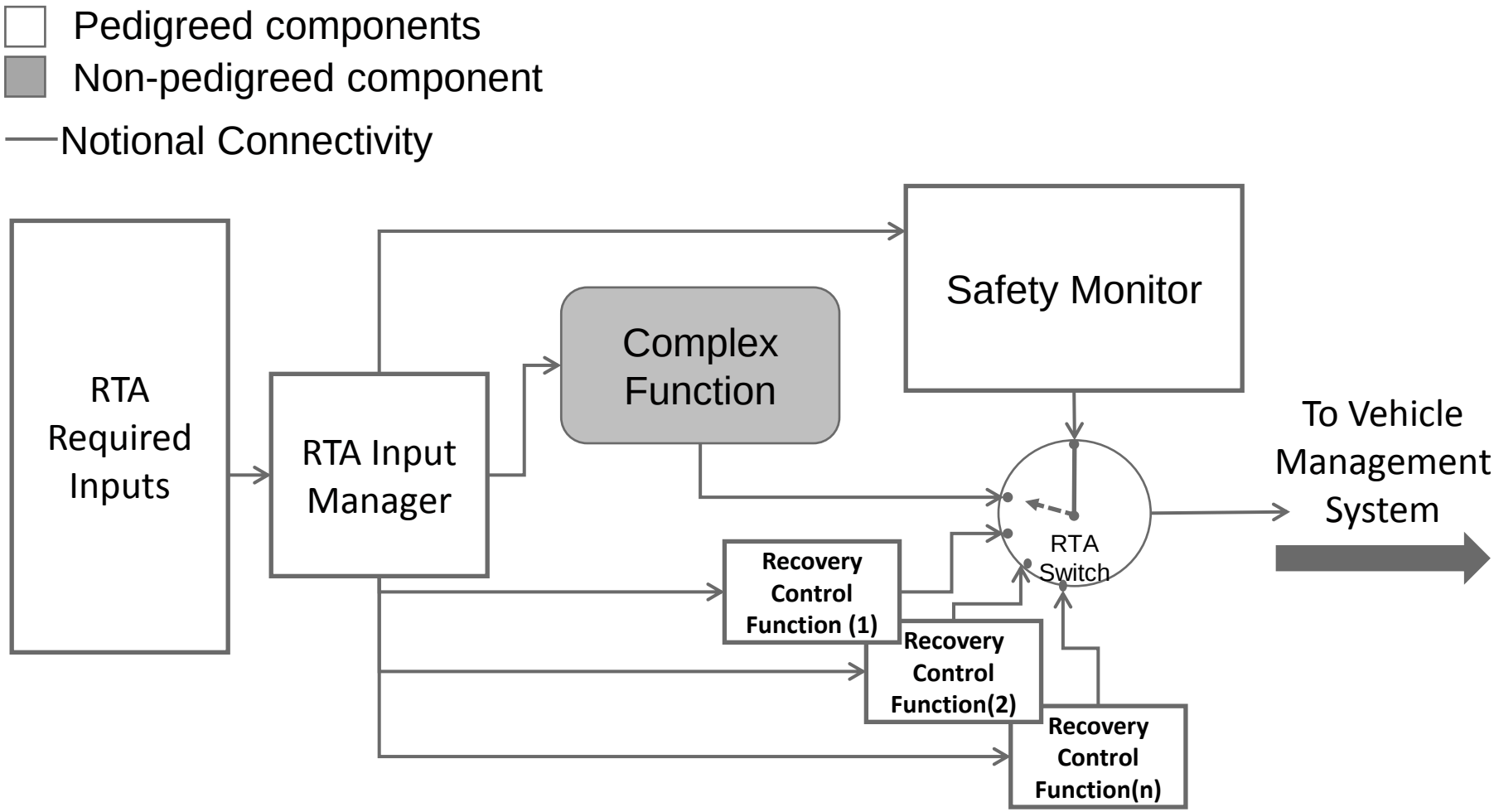
Affirmative	39
Negative	3
Abstain	15
%Affirmative	92.85

- All comments have been dispositioned and significant changes made to second version of standard

- Anticipate balloting to entire F38 this summer

Thank you to F38.01 for the constructive comments!

WK53403 RTA Architecture Components



Some Observations on WK53403 Version 2

- Eliminated “Verification” and “Documentation” requirements for each RTA component
- Verification and Documentation requirements exist at the RTA level
- Retained “Interface”, “Functional”, and “Performance” requirements for each RTA component
- Eliminated “Status Message” from standard
  - Had been an optional input from the Complex Function to the Safety Monitor
- Deleted Appendix X.1 “Example Scenario of an RTA with Two Recovery Control Functions” for clarity
- Clarified that UAS Manufacturer is responsible for performing the operational risk analysis per ASTM F3178-16
- Clarified that RCFs must be capable of sending commands to the RTA Switch that ensure adequate VMS performance
- Reduced the requirement for post-flight data analysis
- Remained agnostic as to whether Complex Function could be used for inner-loop or outer-loop control
  - Definition of VMS in the standard supports both use cases

Way Forward

- Second version of WK53403 in draft, incorporating feedback from first ballot
- Intent to ballot version 2 to entire F38 this summer
- First-of-its-kind standard to support incorporation of complex functions in UAS through use of a Run-Time Assurance Architecture

Design, Construct, and Test

Overview

Designation: **F2910-14**

Approved: 15 Jan 2014

Status: See next chart(s)

Summary:

This specification defines the design, construction, and test requirements for a small unmanned aircraft system (sUAS). It is written for all sUAS that are permitted to operate over a defined unpopulated area and in airspace authorized by a CAA. It is assumed that a visual observer(s) will provide for the sense-and-avoid requirement to prevent collisions with other aircraft and that the maximum range and altitude at which the sUAS can be flown at will be specified by the CAA.

TG Lead:

Ted Wierzbanowski

TG Members:

N/A

(New Task Groups are developing separate standards for Fixed Wing and VTOL sUAS)

Design, Construct, and Test

Status

- Current standard may end up as a “best practice” for operations under the final sUAS 107 rule, 333s, and the EU “Open” category
- If this is done the current standard will require a minor revision (e.g. changing shall to should/may and calling it a guide or practice)
- New “Design, Construct, and Test” standards are being written for other than 107 and 333 applications including EVLOS / BVLOS and Operations over People. They will address FAA and other stakeholder comments, will be more specific, and will be split into two separate standards for:

  - Fixed wing (Jonathan Daniels- Task Group lead)
  - VTOL (Scott Strimple- Task Group lead)

Design, Construction and Verification of Fixed Wing sUAS

Overview

Designation: **WK52962**

Last Balloted: New

Status: See next chart(s)

Summary:

To develop an ASTM standard that defines the requirements for Design, Construct and *Verify** of Fixed Wing sUAS. The standard will address the requirements and/or best practices for design, construction and test of an unmanned aircraft. These are standards of practice for self-, or third-party, determinations of airworthiness for Risk Class 1 and 2 UAS, including waivers of Part 107-like and “Open Category” rules.

TG Lead:

Jonathan Daniels	PACI

TG Members:

Wes Ryan	FAA
Paul Albuquerque	FAA
James Folz	FAA
Jacquelyn Erinne	FAA
Jeff Bergson	FAA
Jon Braam	Amazon
Chris Jackman	X
Wes Ryan	FAA
Andi Meyer	KSU

**”Verify” includes multiple methods: Test, Demonstration, Inspection, and Analysis*

Design, Construction and Verification of Fixed Wing sUAS

Status

- In development since March 2016
  - Built upon original F2910-14 standard
  - Updated with multiple industry best practices (Unmanned Systems Canada, UAS, advanced ultralights, very light aircraft and light sport aircraft) and KSU research
- Conducted Working Group in March at FAA HQ
  - Focused on Risk Class 1 and 2
  - baseline for Part 107 waivers and “type certification”
  - Risk Class
  - References several ASTM standards under development: C2, EVLOS/BVLOS operations, and Operations over people
- Weekly Telecon

Design, Construction and Verification of VTOL sUAS

Overview

Designation: **WK53964**

Last Balloted: New

Status: See next chart(s)

Summary:

The standard builds upon F2910-14 and specifically addresses the requirements and/or best practices for design, construction and testing of VTOL small unmanned aircraft. The intent is for this std to support sUA VTOL aircraft that will require a level of CAA type certification and provide standards of practice for self- or third-party determination of airworthiness for sUAS.

TG Lead:

Scott Strimple	Virginia UAS

TG Members:

Andy Johnson-Laird	
Dr. Robert Klenke	VCU Engineering
Rich Hansen	AMA
Wes Ryan	FAA – ACE114
Walter Stockwell	DJI
Craig Ranta	Aeryon
Ed De Reyes	Water West Ent.
Ajay Sehgal	KBRwyle
Johnhenri Richardson	
James Blyn	FAA – Rotorcraft Directorate

Design, Construction and Verification of VTOL sUAS

Status

- WG activity delayed until finalization of Fixed Wing sUAS design, construction and verification standard FAA face to face meeting in early 2017.
- Removing language that only applies to fixed wing sUAS design to formulate the starting draft
- Team Members finalized
- TOR (Term of Reference) finalized
- Build upon baseline F2910-14 standard, specifically focusing on VTOL sUAS design, construct and testing to address
  - FAA comments on baseline standard
  - 21.17b applications including EVLOS/BVLOS and Operations over people
- Draft standard for EXCOM review expected by late summer 2017

Standard Specification for Design of the Command and Control System for sUAS

Designation: **F3002-14a**

Last Balloted: 15 Dec 2016

Status: See next chart(s)

Summary:

This design specification is intended to provide an industry consensus standard for C2 systems to support an application to a national CAA for operation of a sUAS.

This standard was balloted to revise and update the existing C2 design standard.

TG Lead:

Walter Stockwell (temp)	DJI

TG Members:

Jon Daniels	Praxis Aerospace
Anna Dietrich	Terrafugia
Craig Ranta	Aeryon
Steven Walker	NASA
Ajay Sehgal	KBRWyle
Ravi Jain	FAA
Robert Joslin	FAA

Background and Motivation

- Desire to update existing standard
- Coordinate better with other standards that have been approved in the last two years
- Explicitly include and describe a lost-link functionality

Ballot Response

- Standard balloted to F38 (December 2016)
- 60 Total Comments
  - 22 Negative
  - 33 Substantive
  - 5 Editorial
- Unfortunately, the previous TG lead had to leave after the last ballot. So work was delayed…
- Consideration of dispositions has started.
- This task group needs a new lead! *hint hint*

Cat	#
AFF	59
NEG	2
ABS	18
PCNT	96.7

Thank you to F38.01 for the constructive comments!

Way Forward

- New Task Group Lead needed!
- Continue evaluation of comments, dispositioning
- Should not be difficult – first run through and the comments look reasonable

Use of Batteries

Overview

Designation: **F3005-14a**

Approved: 1 Jun 2014

Status: See next chart

Summary:

This standard relates to and is referenced by other sUAS standards at the sUAS system level. This standard is mandatory at any point in the sUAS system in which batteries are used, except for sub-systems that have no effect on flight safety. The determination of effect on flight safety shall be made by the system designer in accordance with the provisions of F2910, Specification for Design, Construction, and Test of a Small Unmanned Aircraft System (sUAS).

TG Lead:

Vijay Somandepalli, American Robotics

TG Members (and other contributors):

Tom Alfieri Honeywell

Walter Stockwell DJI

Use of Batteries

Status

- Recent History
  - Compilation of material since last revision in 2014
  - Some major changes being incorporated (Deferment of some criteria to system-level standard F2910; Reference to DO-160; Change in QC sampling criteria)
- Current Status
  - Balloting on WK56160 closed Nov 7, 2016
  - 5 Negative votes, 7 votes with comments received
  - Most have been adjudicated
- Outstanding Tasks
  - Re-balloting of updated standard
  - Harmonization with F2910
  - Identify other appropriate industry criteria/standards
  - Begin work on next version of standard incorporating suggestions & changes

Use of Batteries

Harmonization with System-Level Standard

- Conforming vs. Non-Conforming
  - A distinction must be made, defined at the system level, as to whether a pack used in a particular function must conform to the standard or whether a non-conforming battery may be used.
  - Will a failed battery always pose a hazard? – Examples:

    Separate battery for atmospheric sensor

    GPS backup battery

    Ground station

Use of Batteries

Other Industry Standards

- Appropriate Industry Standards for Battery & Cell Quality
  - What are the appropriate industry standards to reference?
  - UL 1642, UL 2054 or UL 62133?
  - Who does the burden of compliance fall on?
- Disposal of EOL batteries and failed batteries
  - What are the appropriate industry standards to reference?
  - If no standards, how do we address this?
- Sampling requirements for Quality Assurance
  - Removed reference to ANSI/ASQ Z1.4-2008
  - Moved to a ‘zero acceptance number’ sampling plan
  - Need to tie this to an underlying industry document/standard.

Use of Batteries

Request for TG expansion

- Task Group Membership
  - Need additional members for the TG
  - Representation from across industry
  - Expanded expertise in different sUAS types and ops

Software Dependability

Overview

Designation: **F3201-16**

Last Balloted: Sep 19, 2016

Status: See next chart(s)

Summary:

The standard intends to establish the dependability of software items in the sUAS that implement functions essential to safety. The dependability includes both the safety and security aspects of the software. It may be used by itself or in conjunction with other standards such as DO-178C, as deemed appropriate by the sUAS manufacturer in accordance with CAA guidance.

.

TG Lead:

Steve Cook	Northrop Grumman

TG Members:

Eric Dunn	AeroVironment
B J Gopinath	Airware
Paul Komarek	Google Project Wing
Andy Lacher	MITRE
Buddy Michini	Airware
Ajay Sehgal	KBRWyle
Robin Sova	FAA
Andrew Slater	PrecisionHawk
Andrew Thurling	AeroVironment
Mike Vukas	FAA

Summary and Next Steps

- Standard for Ensuring the Dependability of Software for UAS –
  <u>First Edition Published 19 September 2016</u>
  - Best Practices from other industries + sUAS Industry Best Practices
  - Safety + Security
  - Externally Developed Software + Internally Developed Software

Designation: F3201 – 16

Standard Practice for
Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)[1]

This standard is issued under the fixed designation F3201; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard practice intends to ensure the dependability of UAS software. Dependability includes both the safety and security aspects of the software.

1.2 This practice will focus on the following areas: (a) Organizational controls (for example, management, training) in place during software development. (b) Use of the software in the system, including its architecture and contribution to overall system safety and security. (c) Metrics and design analysis related to assessing the code. (d) Techniques and tools related to code review. (e) Quality assurance. (f) Testing of the software.

1.3 There is interest from industry and some parts of the CAAs to pursue an alternate means of compliance for software assurance for small UAS (sUAS).

1.4 This practice is intended to support sUAS operations. It is assumed that the risk of sUAS will vary based on concept of operations, environment, and other variables. The fact that there are no souls onboard the UAS may reduce or eliminate some hazards and risks. However, at the discretion of the CAA, this practice may be applied to other UAS operations.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *FAA Standard:*[2]
FAA 23.1309–1E System Safety Analysis and Assessment for Part 23 Airplanes

2.2 *IEC Standard:*[3]
IEC 62304 Medical Device Software—Software Life Cycle Processes

2.3 *ISO Standards:*[4]
ISO 9001 Quality Management Systems—Requirements

2.4 *ICAO Standard:*[5]
ICAO 9859 Safety Management Manual

2.5 *NASA Standard:*[6]
NASA Technical Briefs Making Sense out of SOUP (Software of Unknown Pedigree)

2.6 *RTCA Standards:*[7]
RTCA DO-178C Software Considerations in Airborne Systems and Equipment Certification
RTCA DO-278A Software Integrity Assurance Considerations for Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) Systems
RTCA DO-326 Airworthiness Security Process Specification

2.7 *Military Standards:*[8]
Department of Defense Joint Software System Safety Handbook
MIL-STD-882E Department of Defense Standard for System Safety

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*
3.1.1 *application programming interface (API)*—definition of the inputs and outputs for operations intended for use by other software modules.
3.1.2 *architecture*—architecture is made up of the definition of the sUAS Software components, the data that flows between

[1] This practice is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.01 on Airworthiness.
Current edition approved Sept. 1, 2016. Published September 2016. DOI: 10.1520/F3201-16.
[2] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.
[3] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, P.O. Box 131, 1211 Geneva 20, Switzerland, http://www.iec.ch.
[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.
[5] Available from International Civil Aviation Organization (ICAO), 999 Robert-Bourassa Blvd., Montreal, Quebec H3C 5H7, Canada, http://www.icao.int.
[6] Available from U.S. National Air and Space Administration (NASA), 300 E Street, SW, Suite 3E30, Washington, DC 20546, http://www.nasa.gov.
[7] Available from Radio Technical Commission for Aeronautics (RTCA), 1150 18th St., NW, Suite 910, Washington, DC 20036, http://www.rtca.org.
[8] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

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1

- Discussions ongoing with FAA Small Airplane Directorate, UAS Integration Office, and other airworthiness authorities as to how standard will be invoked (e.g., NOA, AC 21.17(b), etc.)

- Requesting feedback from companies that are using the standard

Production Acceptance

Overview

Designation: **F2911-14**

Approved: 15 Jan 2014

Status: See next chart(s)

Summary:

This standard defines the production acceptance requirements for a small unmanned aircraft system (sUAS).

TG Lead:

Ted Wierzbanowski

TG Members:

Need new members for any revision

Production Acceptance

Status

- Being reviewed by the FAA
  - Generally in good shape. Minimal comments received from the FAA Office of Unmanned Aircraft Systems Integration
  - Still getting comments from the FAA Small Airplane Directorate and production offices
- Revision may, or may not, be required for operations other than what are allowed under Part 107. If so:
  - New Task Group will, most likely, be formed
  - New Task Group leader may also be needed

Quality Assurance

Overview

Designation: **F3003-14**

Approved: 15 Jan 2014

Status: See next chart(s)

Summary:

This standard defines the quality assurance requirements for the design, manufacture, and production of a small unmanned aircraft system (sUAS).

TG Lead:

Ted Wierzbanowski

TG Members:

Need new members for any revision

Quality Assurance

Status

- Being reviewed by the FAA
  - Generally in good shape. Minimal comments received from the FAA Office of Unmanned Aircraft Systems Integration
  - Still getting comments from the FAA Small Airplane Directorate and QA offices
- Revision may, or may not, be required for operations other than what are allowed under Part 107. If so:
  - New Task Group will, most likely, be formed
  - New Task Group leader may also be needed

F38.01 Closing

–New business

- What's Next?

  – Future efforts may include:
    – New standards (as required)
      – SARP
    – Revision to standards based on comments from ballot and FAA review(s)

  – Need qualified and self-driven people
    – Task Group leads
    – Task Group members

F38.01 Closing (cont)

- **New Business**
  - Items from the floor?
- **Summary action items** (Sehgal)
- **Adjournment** *(Action: motion, second, vote)*

Contact Information

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Chairman

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F38.03 *Personnel Training, Qualification and Certification Subcommittee*

ASTM Meeting at TAAC

8 May 2017

Ted Wierzbanowski for Scott Strimple
Chair, ASTM International Subcommittee F38.03

www.astm.org

F38.03 Agenda

- **Call to Order** (W+12)
- **Approval of agenda** *(Action: motion, second, vote)*
- Membership report
- Task group reports
  - Pilot/Visual Observer Training (W+12) – WK29229
  - Aircraft Flight Manual (W+12) – F2908-14
- New business
- Summary of action items (W+12)
- Adjournment

F38.03 Membership Report

Balance Report
As of 5/5/2017 3:01 PM

Producer Votes Available: 34

	Producer	User	Consumer	General Interest	Unclassified	Total
Official Voting Member	7	17	0	24	0	48
Non Official Voting Member	0	3	0	10	38	51
TOTAL	7	20	0	34	38	99

F38.03 Task Group Reports

- Pilot/Visual Observer Training (W+12) – WK29229
- Aircraft Flight Manual (W+12) – F2908-14

Pilot/Visual Observer Training

Overview

Designation: WK29229

Last Balloted: 5 May 2017

Status: In Ballot
See next chart(s)

Summary:

Recognizing the sUA performance capability to operate in the same airspace used by aircraft carrying people, this standard intends to establish the recommended training and knowledge necessary for pilots and visual observers to conduct safe sUAS operations.

TG Lead:

Scott Strimple

TG Members:

Andy Johnson-Laird	Johnson-Laird, Inc.
Dave Miller	
Gus Calderon	Airspace Consulting
Silas Stills	FAA
Ted Wierzbanowski	

Pilot/Visual Observer Training

Status

- Streamlined original WK29222 document to remove regulatory and certification language
- Re-organized knowledge and practical experience content
- Developed more detail on training requirements for systems that are flown manually or are highly automated or a combination of either

Aircraft Flight Manual

Overview

Designation: F2908-14

Approved: 15 Jan 14

Status: See next chart(s)

Summary:

This specification provides the minimum requirements for an Aircraft Flight Manual (AFM) for an unmanned aircraft system (UAS) designed, manufactured, and operated in the small UAS (sUAS) category as defined by a National Aviation Authority (NAA). Depending on the size and complexity of the sUAS, an AFM may also contain the instructions for maintenance and continuing airworthiness for owner / operator authorized maintenance.

.

TG Lead:

Ted Wierzbanowski

TG Members:

Not active

Aircraft Flight Manual

Status

- Still working with FAA on process to issue a FAA Notice of Availability (NOA) on this standard

F38.03 Closing

- **New business**
  - Items from the floor?
- **Summary of action items** (W+12)
- **Adjournment** *(Action: motion, second, vote)*

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F38.02 *Flight Operations Subcommittee*

ASTM Meeting at AUVSI XPONENTIAL 2017

8 May 2017

Mark Blanks
Chair, ASTM International Subcommittee F38.02

www.astm.org

Agenda – F38.02

- **Call to order** (Blanks)
- **Approval of agenda** *(Action: motion, second, vote)*
- Membership report
- Task Group reports
  - Maintenance and Continued Airworthiness (Blanks) – WK53686
- Standards Requiring Review
- Summary of action items (Blanks)
- New business
  - Items from the floor?
- Adjournment

F38.02 – Operations

–Membership Report : *Subcommittee is balanced: 13 producer votes available.*

Balance Report
As of 5/4/2017 10:32 AM

Producer Votes Available: 13

	Producer	User	Consumer	General Interest	Unclassified	Total
Official Voting Member	38	32	0	19	0	89
Non Official Voting Member	6	5	0	6	0	17
TOTAL	44	37	0	25	0	106

Ballot Results and Task Group Reports

– Maintenance and Continued Airworthiness (Blanks) – WK53686

Maintenance and Continued Airworthiness Overview

Designation: **WK53686**

Last Balloted: 2014

Status: Developing revision to F2909-14

Summary:

This specification establishes the standard practice for the maintenance and continued airworthiness of sUAS.

TG Lead:

Mark Blanks

TG Members:

Core	
Mark Blanks	MAAP/Virginia Tech
Rob Winn	FAA
Bob Keenum	FAA
Brad Hayden	Robotic Skies
Jon Daniels	Praxis Aerospace
Charles Nick	K-State
Zackary Nicklin	NCTC
Dave Satterfield	NASA
Advising	
Ajay Sehgal	Wyle
Silas Still	FAA

Maintenance and Continued Airworthiness Status

- Increased size and expertise of task group
- Key Discussions to Date:
  - Requiring manufacturer provided maintenance instructions (shall vs. should)
  - “Manufacturer provided” versus “operator developed” maintenance programs
    - TC’d aircraft (manned) have approved maintenance programs
    - How do you develop a “continued airworthiness” program without an initial finding of airworthiness?
    - How does an owner/operator generate data to determine continuing airworthiness requirements?
  - Eliminating vague language, i.e. “high probability”
  - Addressing UAS versus sUAS, what changes at 55 lbs.?
  - Where does preventative maintenance stop and significant maintenance begin with UAS?

Maintenance and Continued Airworthiness Status

- Current Status
  - Large task group = intense discussions = slow progress
  - Added Co-Lead (Brad Hayden) to assist in managing task group
  - Sections 1-4 updated, opening requirements of Section 5: Requirements finalized
  - New strategy for remaining work:
    - Task group lead (Blanks) and co-lead (Hayden) working on a new version of Section 5: Requirements
    - Leads will bring new version to task group for review before ballot

- Timeline
  - June 2017: Task group leads finish revised language
  - ~July 2017: Ballot first draft of revision

F38.02 – Operations Closing

- **Standards Requiring Review**
  - F2849-10 Standard Practice for Handling of Unmanned Aircraft Systems at Divert Airfields (Overdue)
    - *Need Technical Contact to lead review for ballot action*
- **Summary Action Items** (Blanks)
- **New Business**
  - Items from the Floor?
- **Adjournment** *(Action: motion, second, vote)*

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Main Committee Closing

ASTM Meeting at AUVSI

8 May 2017

Ted Wierzbanowski (W+12) - Chair, ASTM International Committee F38
Mary Mikolajewski (M+11) – Staff Manager, ASTM International Committee F38

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Agenda – F38 Main Committee Closing

- **Call to order** (W+12)
- **Approval of the agenda** *(Action: motion, second, vote)*
- **Reports**
  - **F38.01 (Sehgal)**
  - **F38.02 (Blanks)**
  - **F38.03 (W+12)**
  - **Staff Report (M+11)**
- **Summary action items (W+12)**
- **New business**
  - Items from the floor?
- **Future meetings**
  - **Face to face meeting in Virginia in the fall?**
  - **TAAC in Dec?**
- **Adjournment** *(Action: motion, second, vote)*

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Background Charts

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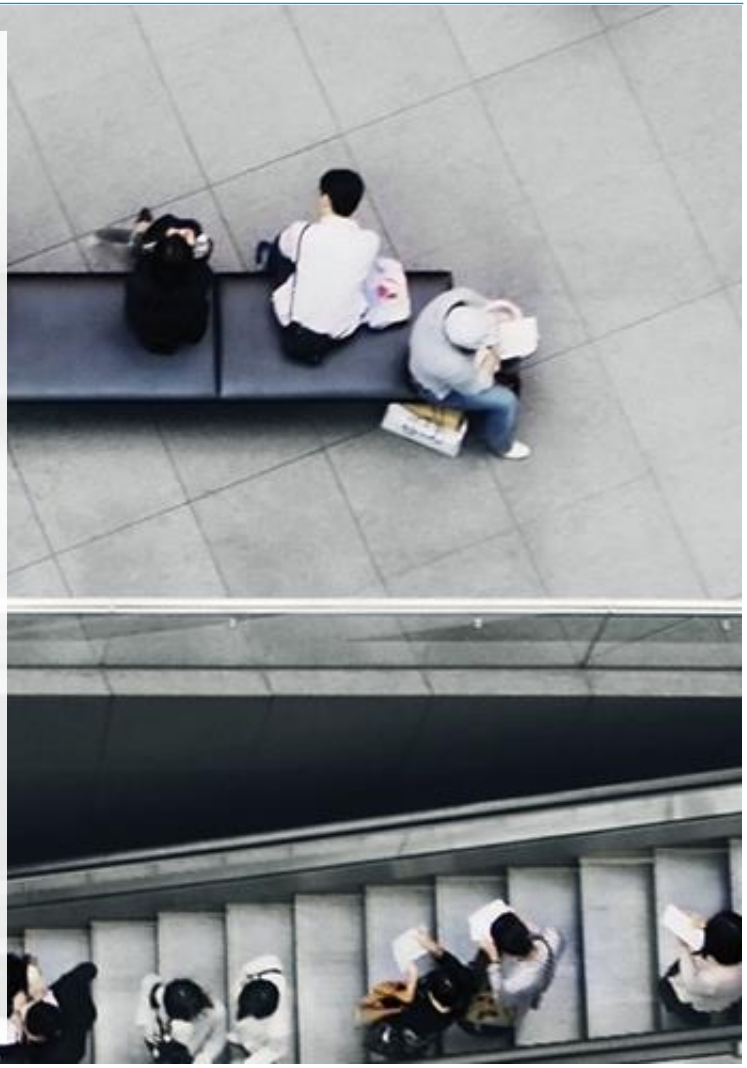
ASTM Background
Touching Every Part of Everyday Life

Introduction

- 12,000+ ASTM standards operate globally
- Combined with our innovative business services they enhance performance and create confidence
- Across borders, disciplines, and industries
- Harnessing the expertise of over 30,000 members
- Across manufacturing and materials, products and processes, systems and services
- Touching every part of everyday life: helping our world work better



ASTM Background
Effective and Relevant Around The World

The Role of Standards

- We rely on our members' expertise and commitment – their good science, good engineering and good judgment
- Recognizing expertise not geography – 148 countries are represented by our members
- Our voluntary consensus process gives everyone an opportunity to participate – ensuring standards are effective and relevant across diverse markets
- Our standards help everyone: consumers, businesses, manufacturers, innovators and governments
- Embracing all the principles of the World Trade Organization's Agreement on Technical Barriers to Trade
- Incorporated into contracts, regulations, codes, and laws, they support established and emerging economies and free and fair global trade

ASTM Background
Improving Standards and Performance

Continuous Improvement and Added Value Services

- We recognize the need to meet changing market needs, regularly reviewing our standards and creating new ones
- We also deliver value-added services that enable customers to get the most out of our standards:
  - ASTM Compass® gives 24/7 access to our content, plus tools to manage, collaborate and learn
  - Our training, testing and certification programs ensure quality and improve performance
- Ultimately, like our founders, we're ready to innovate, we value good sense, we're willing to share and be accountable.
- Above all – we're committed to helping our world work better

ASTM Background
Aviation Standards

A Spectrum of Standards & Regulations:

Exempt from FARs by Definition

Kites
Models

Regulation by FAA-Recognized 3rd Party Involvement
e.g., FAR Part 103

Sanctioned Industry Standards and Programs for Safe Construction and Operation
USHPA SOPs

Regulation by Self-Declaration to FAA-Recognized Consensus Standards
Light Sport Aircraft

Consensus Standards are Primary Means of Establishing Compliance
ASTM Committee F37

Heavily Regulated
Normal, Utility, Transport Categories

FAR Parts Supported by TSOs, Consensus Standards, and Formal TC/PC processes

FAA Update

Standards Overview and UAS Update

Presented to: ASTM F38

By: Wes Ryan, Aircraft Certification Service

Date: May 8, 2017

Discussion Points

- **Advantages**
- **Challenge of Many Players**
- **Strategy**
- **Focus – Now, Next, Long Term**
- **Update on Existing Efforts**
- **Technical Exchange**
- **Test Sites/Pathfinders**
- **Positive Notes**

Advantages of Industry Standards

- **Helps us keep pace with technology**
- **Provides Industry-based definition of acceptable safety standards**
- **Globally acceptable**
  - Single standard accepted by multiple authorities
- **Legally defensible foundation**
  - Keeps any single authority from driving to conservative level of safety
  - Reduces liability of company if they meet accepted standard

Advantages, Cont'd

- **OMB Circular 119 encourages the use of consensus standards as much as practicable in our future rulemaking**
- **That is one of the motivations behind their use in our part 23 rewrite**

Many Players

- **ISO, ANSI, NIST, RTCA, JARUS, ICAO, ASTM, SAE, all working/coordinating standards**
  - Each standards body has inherent expectations for timelines, process, and product delivery
  - These may dictate who is best for a particular standard – ie. international vs. domestic, etc.
- **Need to create a matrix of skills, strengths, and standards being worked**
  - Leverage Strengths vs. Industry Needs
  - Standards for Avionics/Equipment vs. Ops Integration
  - Avoid Duplication of Efforts, or assignment to “wrong” group.

Strategic Direction

- **Should focus on immediate, mid, and long term goals**
  - Now – D&C, Standard Injury Test Methods (Drop Test, Parachute Stds.) – Feed Waivers, Exemptions, Safety Case for Operations, etc.
  - Next - OOP and BVLOS < 400 ft for Infrastructure
  - Long – Automation & Integration – Deconstructed Pilot Tasks and Standards, Best Practices for Assured/Reliable Autonomy

Use of Standards

Basic 107 Operations

No Airworthiness

Operational Rule

Expanded Operations

Ops Related Standards for CONOP

FXXX OOP

FXXX EVLOS

Foundation

F2910 D&C

Operational Rule

Focus Now

- **Design and Construction – Key Foundation to Other Standards**
  - Foundation for basic integrity to allow expanded ops beyond 107
- **Standard Test Practices for Human Injury**
  - Design characteristics to avoid injury from impact and rotating parts
  - Drop test standards, parachute standards, etc.
- **sUAS EVLOS Low Altitude (Other Niche Operations)**
  - Focus on needs for mission – ie. design and equipage for specific use cases with low risk to the NAS but high value to industry
  - Standard should be independent of FAA process - ie. applicable to waivers, exemptions, airworthiness, type design, etc.

Test Sites/Pathfinders

- **Still Seeking Better Connection to Test Sites and Lessons Learned from Pathfinders**
  - Operational Safety Procedures
  - Collision Avoidance Strategies
  - Technologies used for Airborne and Ground Based management of the flight and other aircraft
  - Lessons learned for maintenance, daily operations, handling, safety, pilot/observer tasks, etc.

Focus Next

- **Allowing expansion beyond small UAS low altitude use cases – what is of value to the industry**
- **UTM solutions and integration into class B below commercial traffic**
- **Concentrate on DAA/C2 needs for EVLOS**
- **Needs for expanding 107 or meeting intent of equipage for part 91**

Focus Long Term

- **Automation taking over tasks for pilot with "monitor" on ground**
  - Swarms, cargo delivery, leading eventually to passenger service
- **Deconstruction of pilot tasks – GAMA and FAA working this already**
  - Communicate, Navigate, etc.
  - Pilot is expected to perform safety related duties in current NAS
  - How will things evolve and what standards are needed?

Update on Existing Standards

- **NOA Process – No longer a “hold”, but existing efforts will require wider coordination than prior standards due to visibility of UAS**
- **Waiting on D&C Standard – Foundational to others being issued**
  - Going beyond 107 will require D&C as foundation, and then additional standards for OOP, BVLOS, etc.
  - Does not make sense to issue other standards prior to main standard being completed

Future, Technical Exchange

- **Planning Event To Facilitate Near Term Goals**
  - Have Key Pathfinder Players, FAA, ASTM, and others in one place
  - Discuss how standards can be documented, tested for validity of content, and published more efficiently based on experience
  - Test Sites Could Assist with Lessons learned and best practices

Positive Notes

- **Having OEMs in the F38 standard for D&C has been HUGE - Also thank you to Jon Daniels**
- **Having clarity from 107 rule has been helpful, but delays due to security concerns have held us up**
  - Can still use standards in support of waivers, exemptions, 333, TC, etc.
  - Standard test method has largest immediate applicability – R&D released that may assist the process

Questions?

Standard Test Methods to Evaluate Response Robot Capabilities and Operator Proficiency for Emergency Response Applications

Developed By:

Adam Jacoff, Kamel Saidi

Intelligent Systems Division, Engineering Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce

Sponsored By:

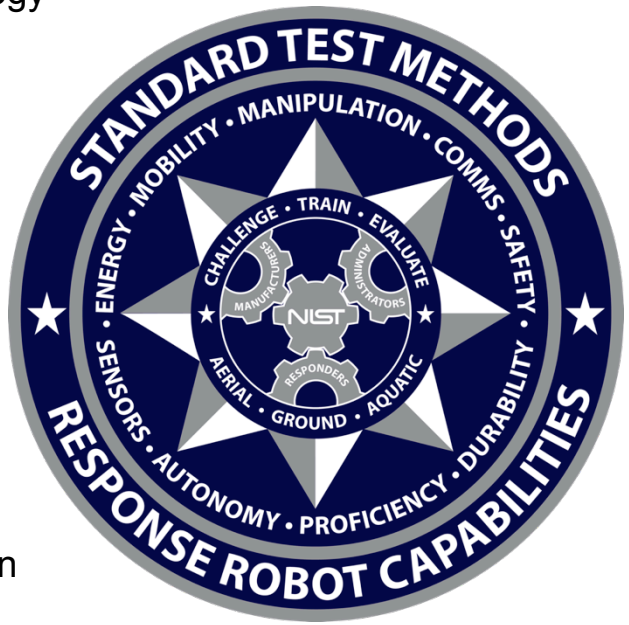
Phil Mattson, Kai-Dee Chu

Office of Standards
Capability Development Support Group
Science & Technology Directorate
U.S. Department of Homeland Security

Standardized Through:

Mary Mikolajewski

ASTM International Standards Committee on
Homeland Security Applications
Response Robots (E54.09)



For more information:
Email: RobotTestMethods@nist.gov | https://RobotTestMethods.nist.gov

Project Purpose

Remotely operated robots enable emergency responders to perform extremely hazardous tasks from safer stand-off distances. But they need ways to determine if a particular robot is capable and reliable enough to perform essential mission tasks.

Comprehensive suites of standard test methods help manufacturers improve capabilities and reliability. They also help users and acquisition professionals objectively evaluate system capabilities and align them with mission requirements.

This improves the safety and effectiveness of emergency responders as they save lives and protect property in our communities.

Project Overview

Objective

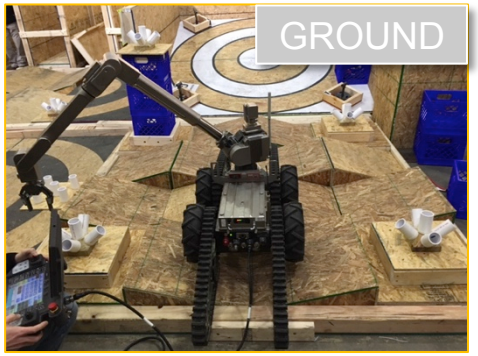
Develop the measurements and standards infrastructure necessary to quantitatively evaluate robot capabilities and operator proficiency.

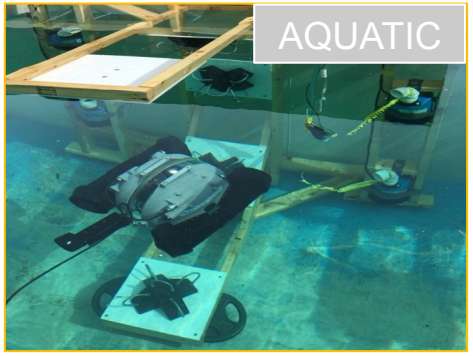
Outcomes:

Test methods, performance metrics, and data collection tools to help manufacturers apply emerging technologies toward essential robot tasks and improve product reliability.

Impacts:

Emergency responders use quantitative data to compare, purchase, train, and deploy robotic systems to perform extremely hazardous missions from safer standoff distances.

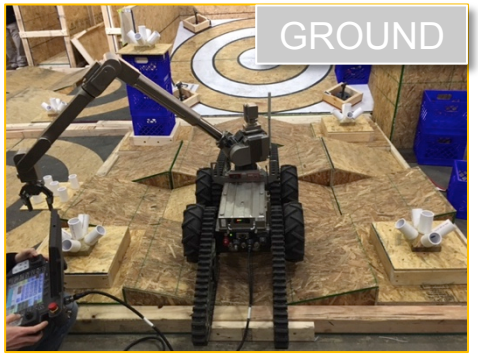


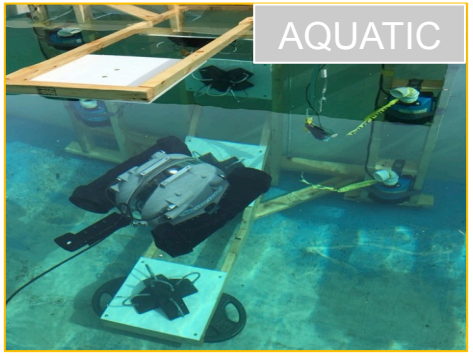


Project Approach

REPEAT

- **Develop** suites of test methods, performance metrics, and data collection tools for Maneuvering, Mobility, Dexterity Sensing, Energy, Comms, Durability, Safety, Autonomy, and Operator Proficiency.
- ***Measure*** combinations of capabilities and emerging technologies.
- ***Inspire*** innovation using tests to communicate operational needs.
- ***Guide*** purchasing and deployment decisions with objective robot capabilities data.
- ***Focus*** training with repeatable tasks and measure operator proficiency.
- ***Identify*** gaps in equipment and/or training through local, regional, or national averages.

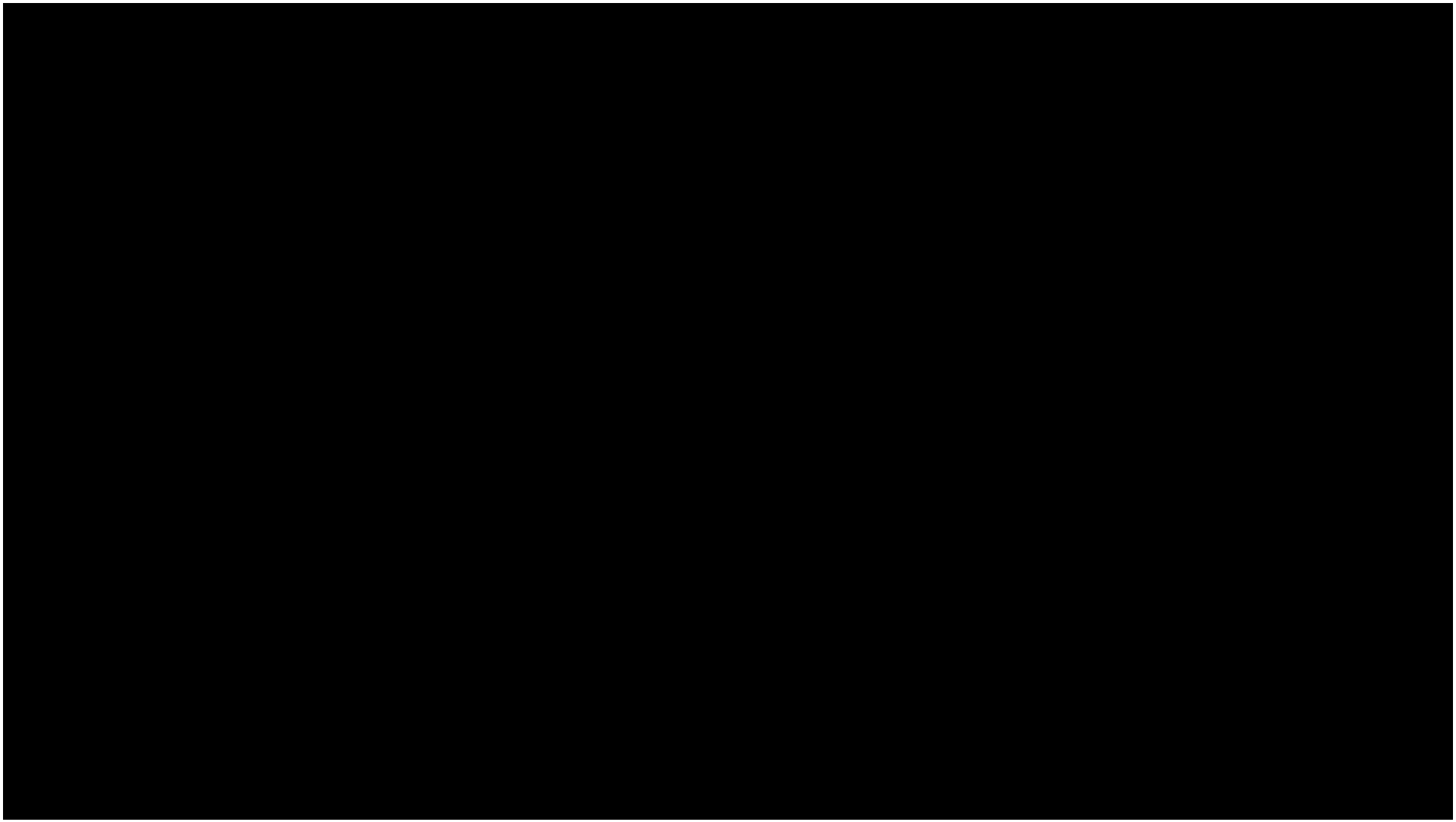




NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods for Response Robots

ASTM International Standards Committee on
Homeland Security Applications; Response Robots (E54.09)



For more information:
Email: RobotTestMethods@nist.gov | https://RobotTestMethods.nist.gov

Implementing Standard Test Methods

Safety | Capabilities | Proficiency

Elemental Testing

Repeat to measure ***capabilities.***

Identify and fix weaknesses.

Practice and evaluate <u>task</u> proficiency with quantitative scores in timed trials.

Combine and Sequence

Repeat to measure ***trade-offs.***

Increase complexity in stepwise ways.

Practice and evaluate <u>mission</u> proficiency with quantitative scores in timed trials.

Embed into Scenarios

Repeat to measure ***readiness.***

Involve uncontrolled variables.

Practice and evaluate <u>readiness</u> with quantitative scores in timed trials.

Deploy

A Model for Standards Collaboration

Safety | Capabilities | Proficiency

Standard Test Methods to Evaluate Robots and Operators

- Measure robot capabilities and reliability in statistically significant trials.
- Compile and disseminate data.
- Fill gaps in tests.

Equipment Standards for Robots in Specific Missions

- Define mission specific suites of ASTM standard test methods.
- Set thresholds to guide purchases and acceptance testing.
- Set thresholds to guide operator proficiency.

Use the Standards to Purchase, Train, and Assess Readiness

- Self evaluate to meet specified thresholds in time limited trials.
- Measure strengths and practice weaknesses.
- Learn how emerging technologies may help.
- Identify gaps in tests.

Deploy

Capture Quantitative Data, Then Select Thresholds

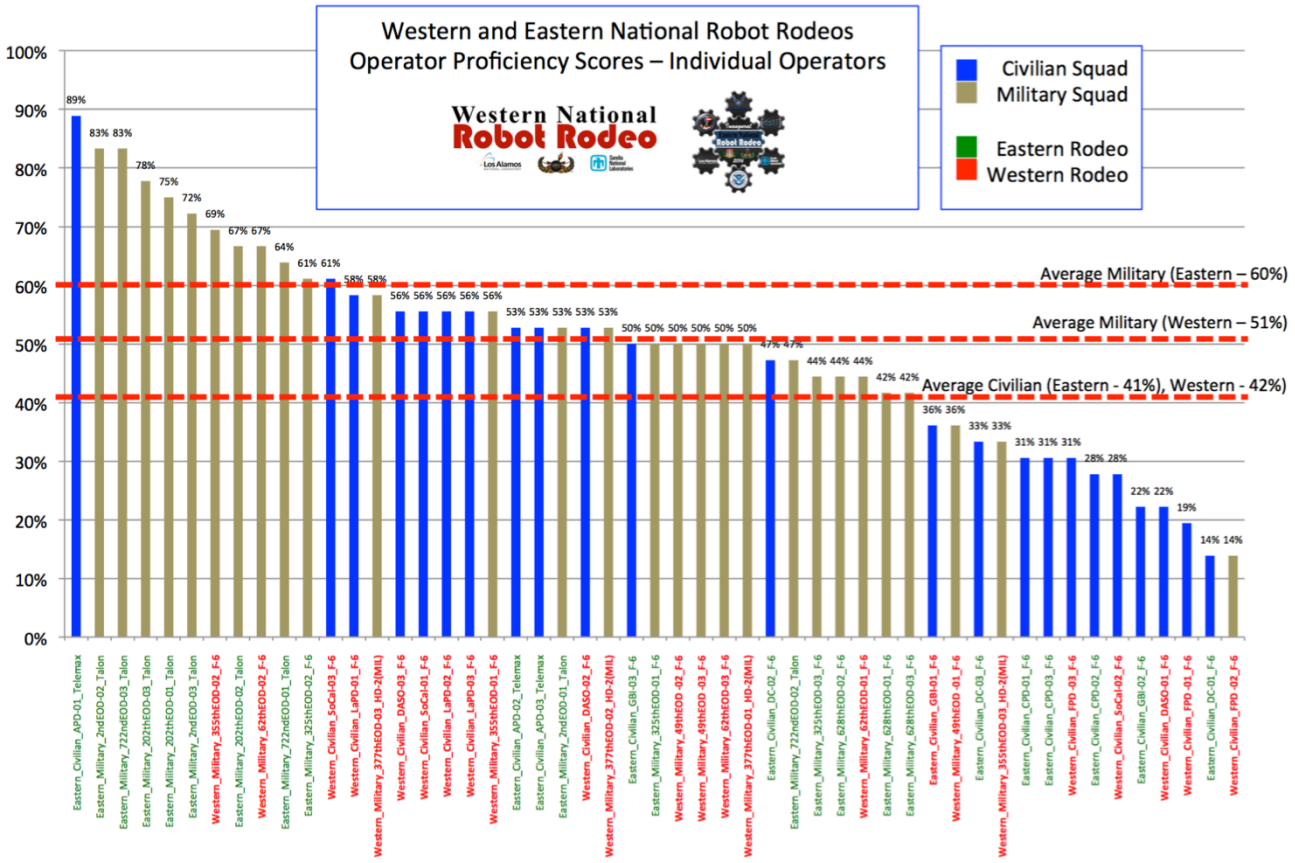
Safety | Capabilities | Proficiency

ASTM INTERNATIONAL

Develop standard test methods and collect robot capability and reliability data with "expert" operators

NFPA®

Select standard test methods and set thresholds to define readiness for mission essential tasks (or adopt user averages)



Test Methods for sUAS

Safety | Capabilities | Proficiency

Up to 25kg (55 lbs) with Vertical Launch and Landing
(Potentially based on Impact Forces rather than weight.)

Impact Forces Test Method

Safety | Capabilities | Proficiency

Abbreviated Injury Scale (AIS) --- **Qualitative**

- 1 Minor
- 2 Moderate
- 3 Serious (CURRENT FAA LIMIT FOR REPORTING INJURIES)
- 4 Severe
- 5 Critical
- 6 Maximal (untreatable)

Range Commanders Council (RCC) --- **Quantitative**

Table 6.1 INJURY THRESHOLDS

Hazard Mechanism	Injury Level	Threshold Value
Blunt trauma	Casualty	11 ft-lb
Blunt Trauma	Fatality	25 ft-lb
Chunky penetration	Casualty	34 ft-lb/in^2
Overpressure	Casualty	2 psi

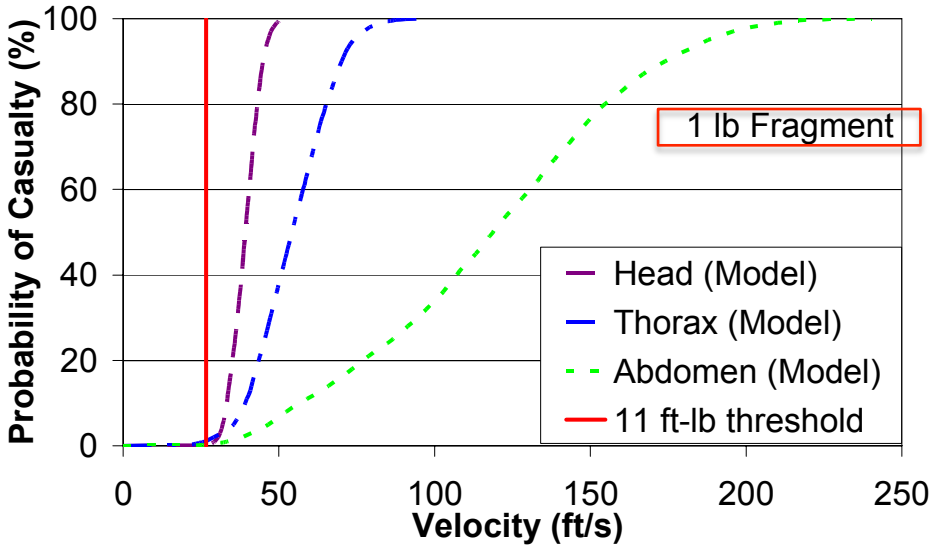
"Common Risk Criteria Standards for National Test Ranges: Supplement", RCC 321-07

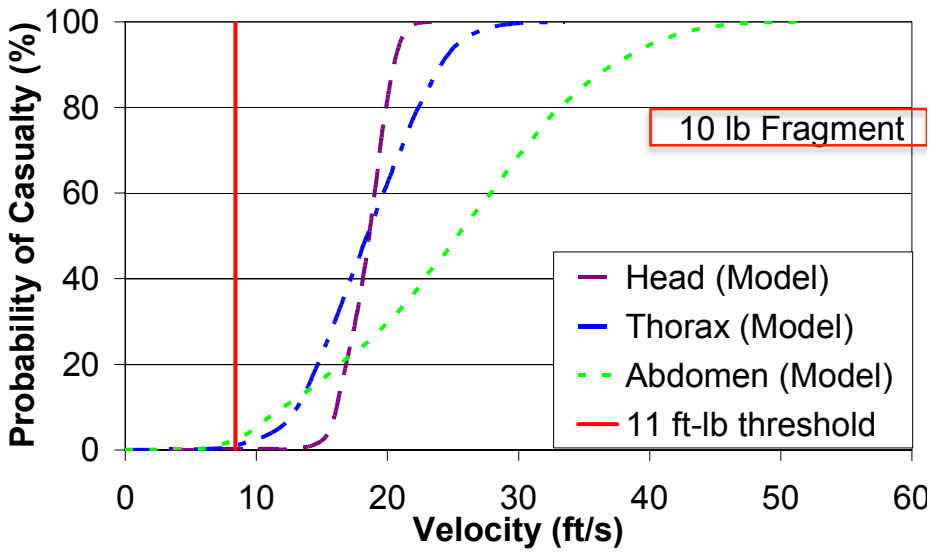
Impact Forces Test Method

Safety | Capabilities | Proficiency

Range Commanders Council (RCC) Hazard Threshold for Unsheltered People

11 ft-lb Criterion Compared to Probability of Casualty (not fatality) Curves





"Common Risk Criteria Standards for National Test Ranges: Supplement", RCC 321-07

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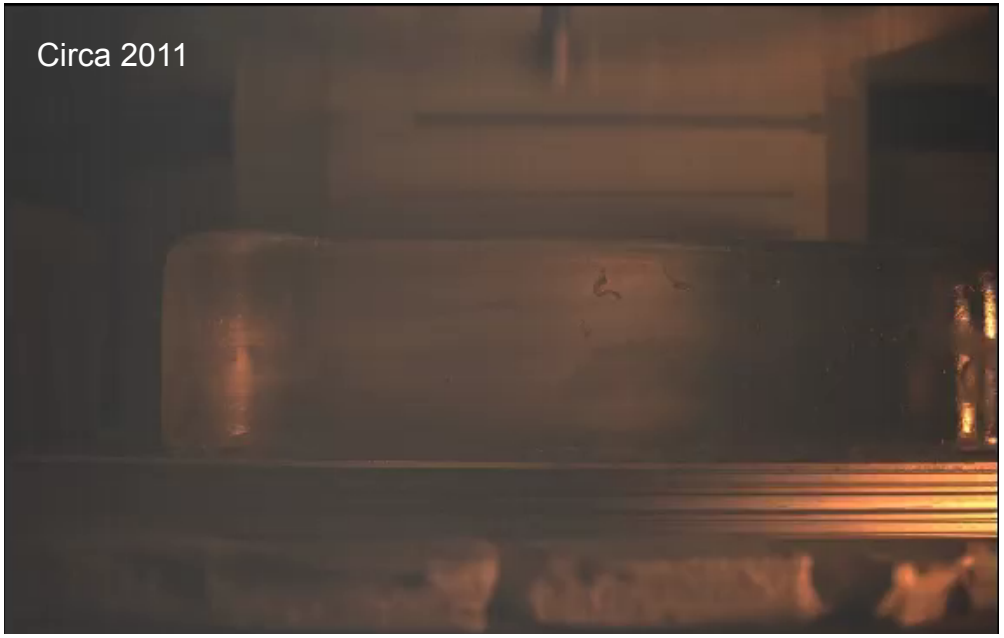
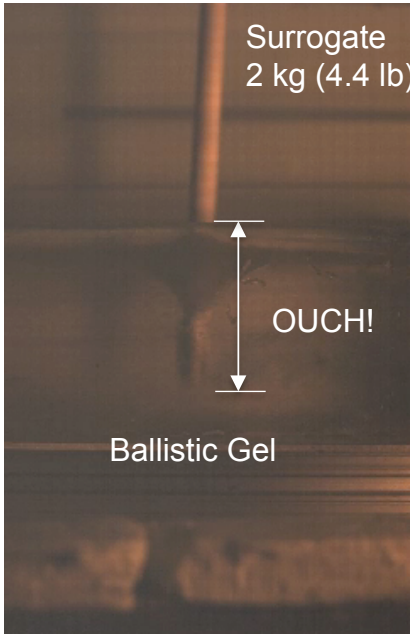
Impact Forces Test Method

Safety | Capabilities | Proficiency

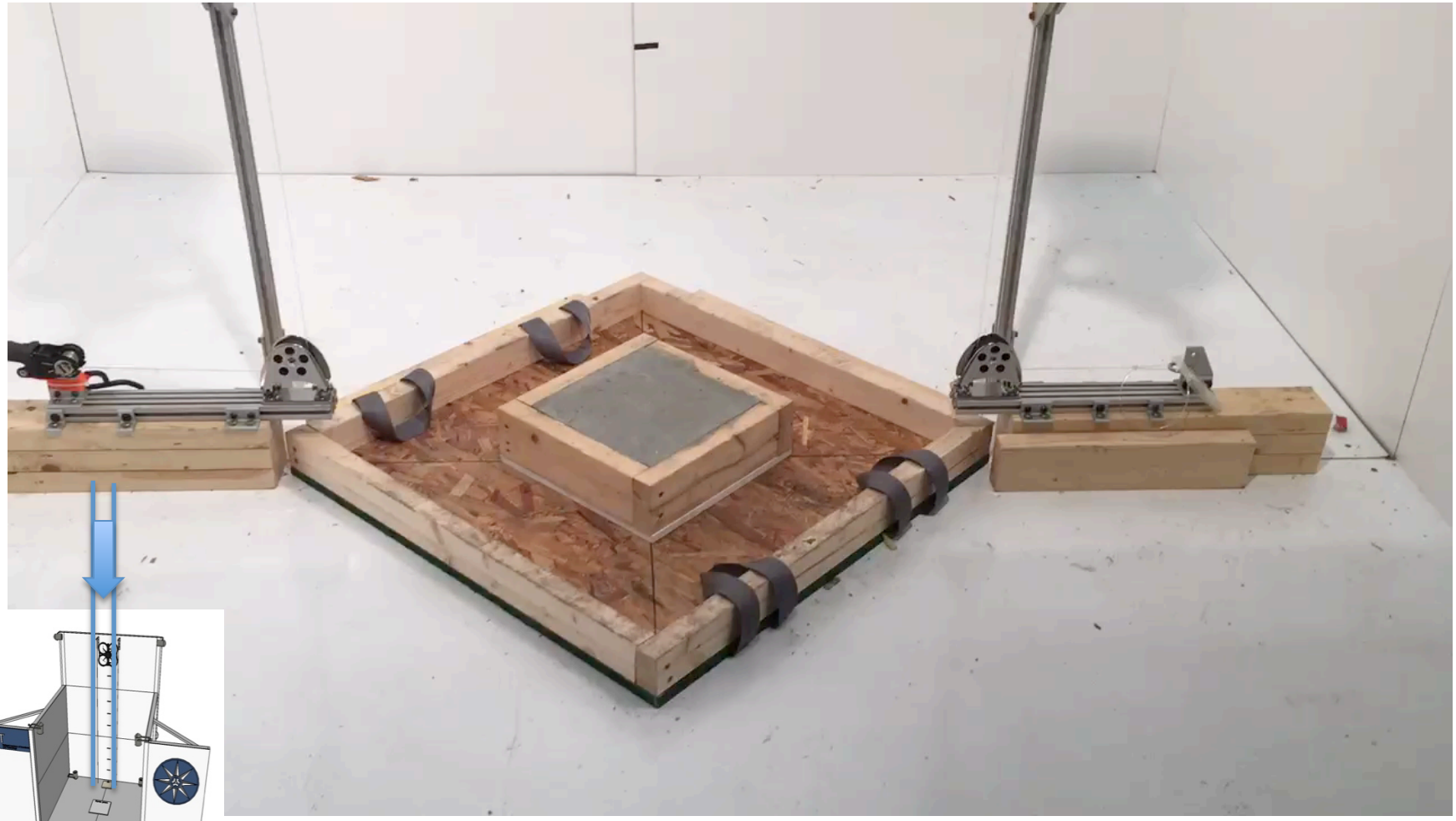
- Force (N)(lbf);
- Pressure (kPa)(psi);
- Penetration (mm)(in)





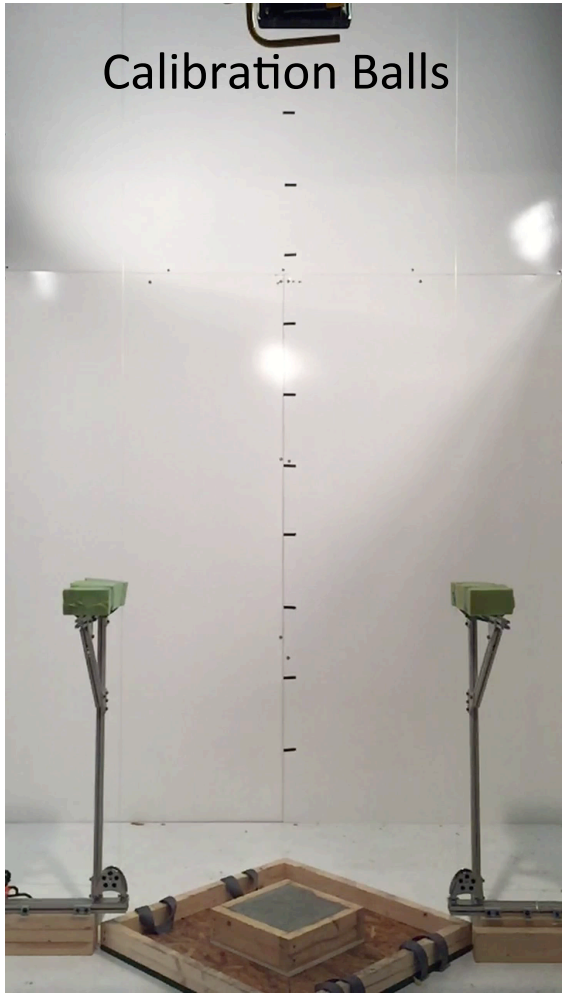
Impact Forces Test Method

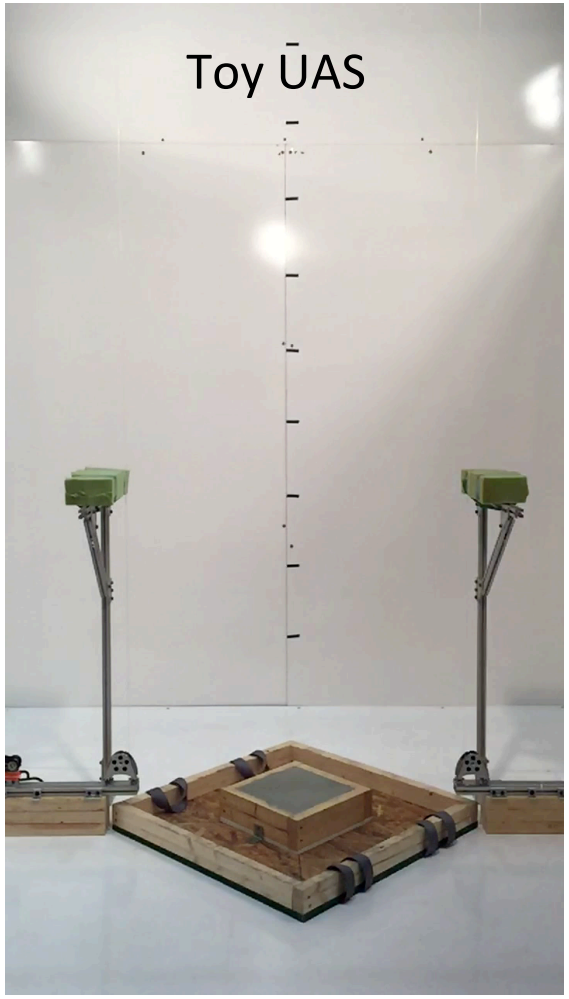
Safety | Capabilities | Proficiency

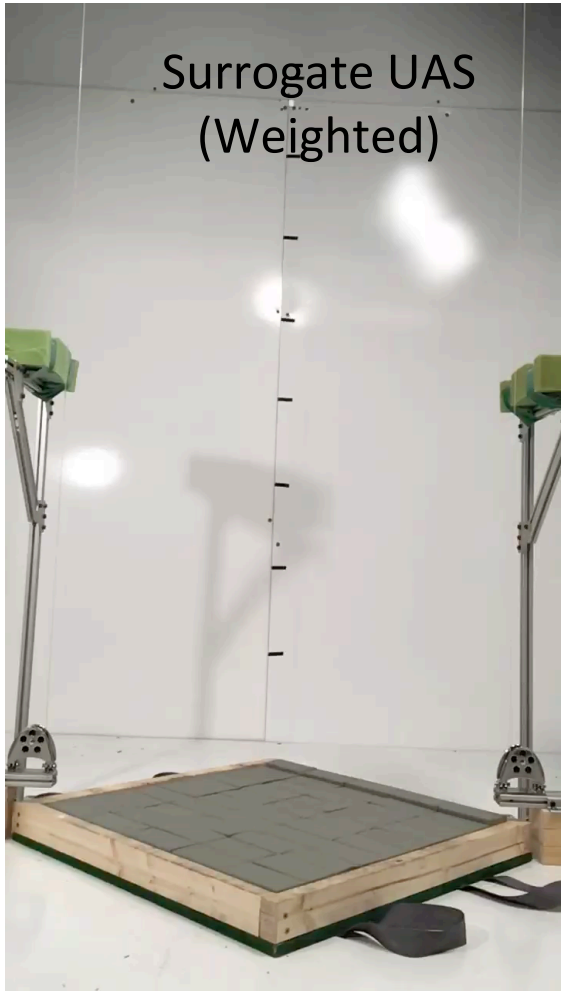


Impact Forces Test Method

Safety | Capabilities | Proficiency

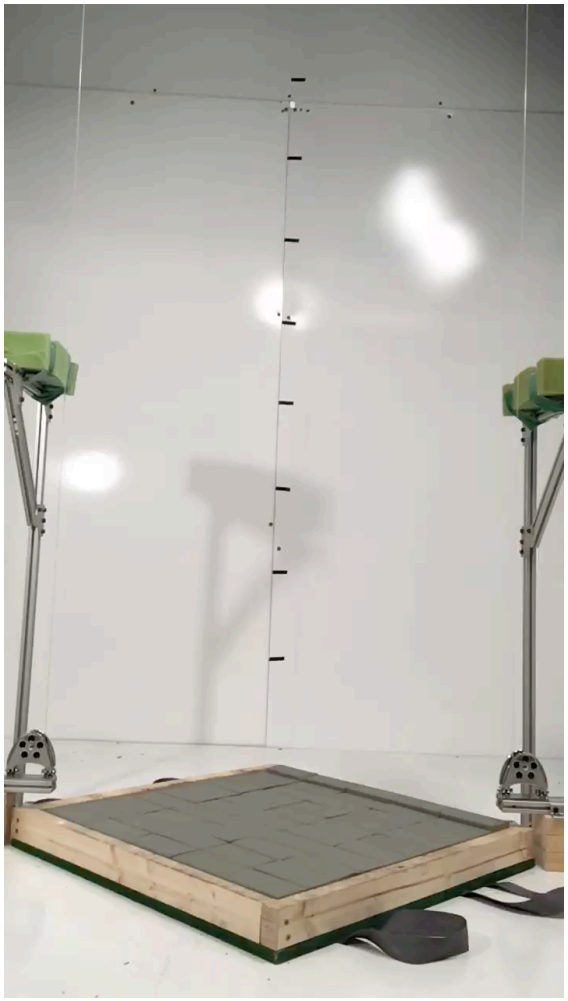






Impact Forces Test Method

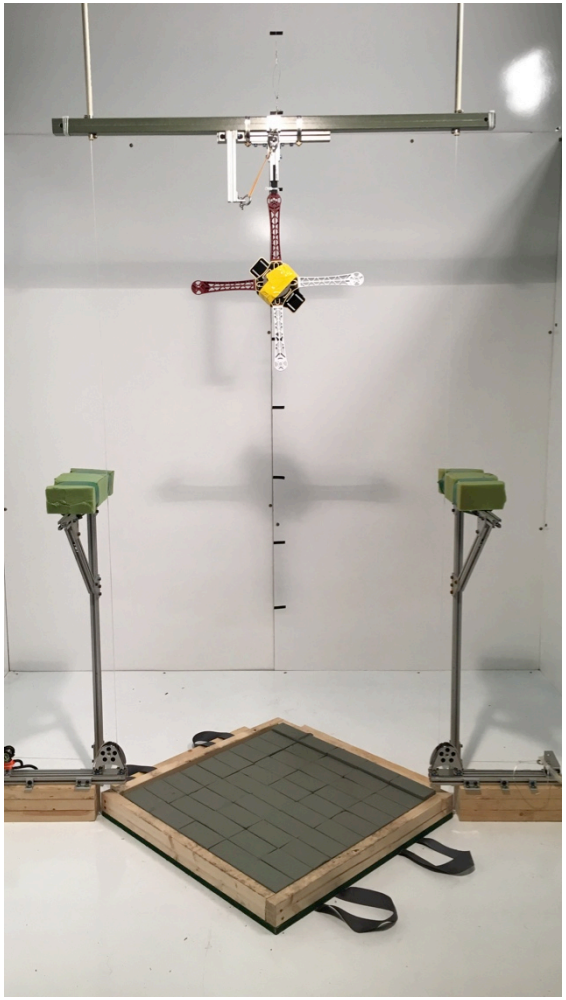
Safety | Capabilities | Proficiency



Surrogate sUAS:

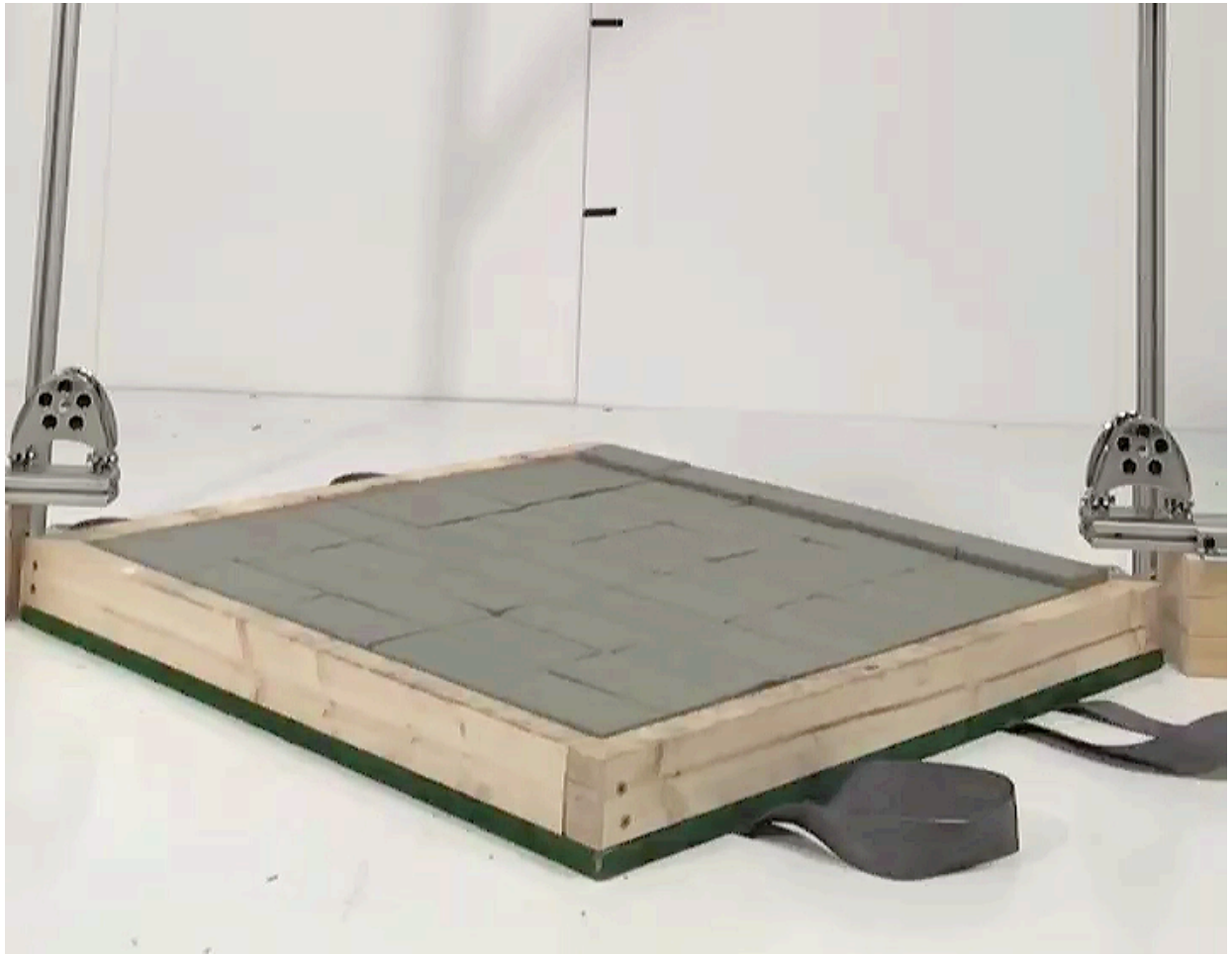
- Weight: 2 kg (4.4 lb)
- Width: 500 mm (20”)
- Drop height: 25 m (80 ft)
- Velocity: 23.2 m/s (52 mph)

Tray with ”ballistic” clay
100 x 100 x 7.4 cm
(40 x 40 x 3 in)



Impact Forces Test Method

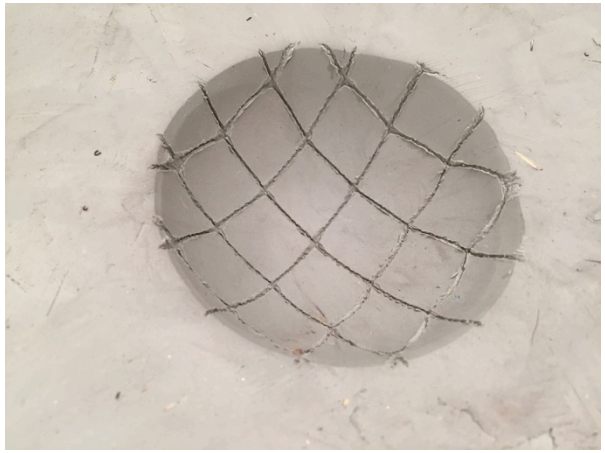
Safety | Capabilities | Proficiency

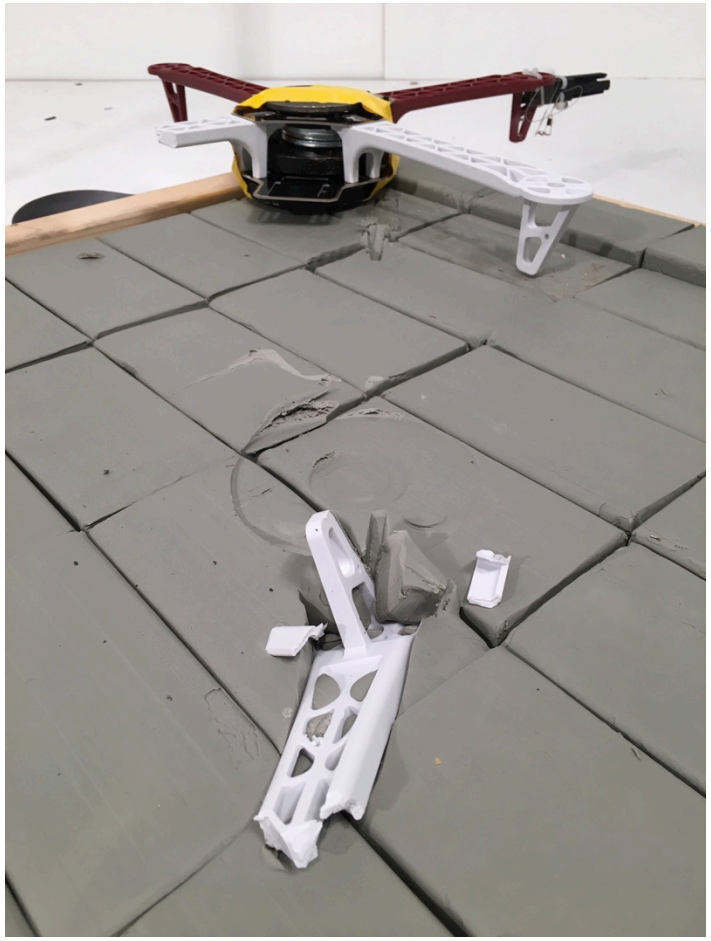


Impact Forces Test Method

Safety | Capabilities | Proficiency

Called the “Witness” by Ballistic Testers

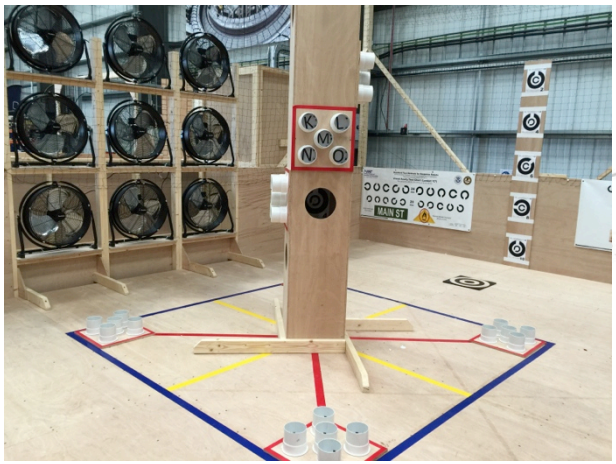


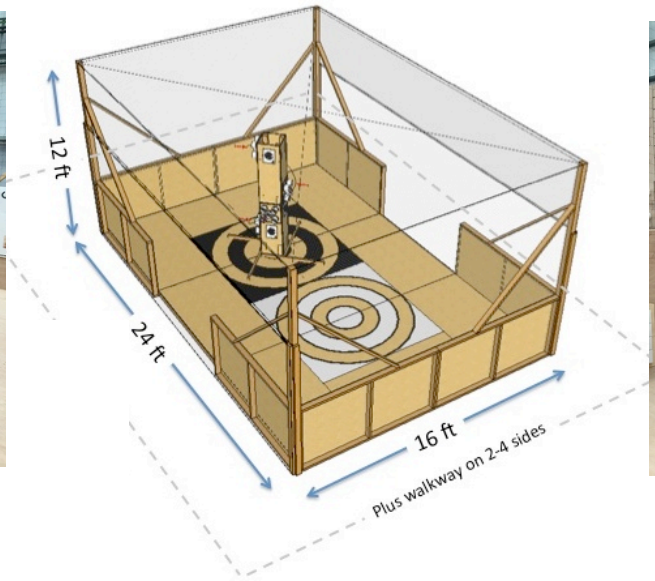


Enclosed Practice/Test Environments

Safety | Capabilities | Proficiency

- Limit safety issues to quickly implement a standards-based approach.
- All testing is in netted enclosures (outside tents when GPS capabilities are involved).
- Users train indoors (tennis or basketball court) to avoid practice in the National Airspace.





Enclosed Practice/Test Environments

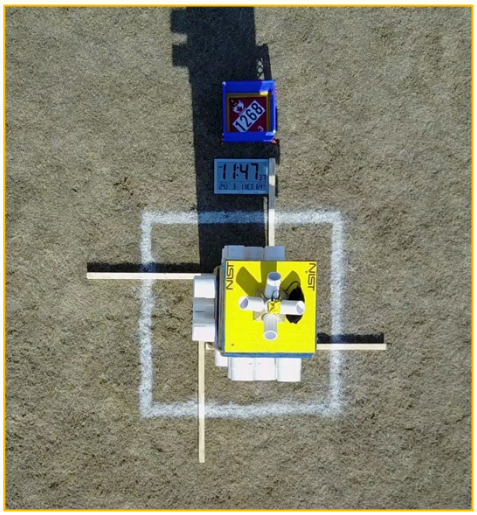
Safety | Capabilities | Proficiency

- Limit safety issues to quickly implement a standards-based approach.
- All testing in netted enclosures (outside nets/tents when GPS is involved).
- Users train indoors (tennis or basketball courts) to avoid practicing in the National Airspace before establishing some level of proficiency.

Outdoor sUAS Test Methods

Safety | Capabilities | Proficiency

- Hold Position and Orientation
- Point and Zoom Cameras (optical, thermal)
- Inspect Targets (downward, spiral, omnidirectional)
- Endurance (with and without max payload)
- Map Area with Stitched Images



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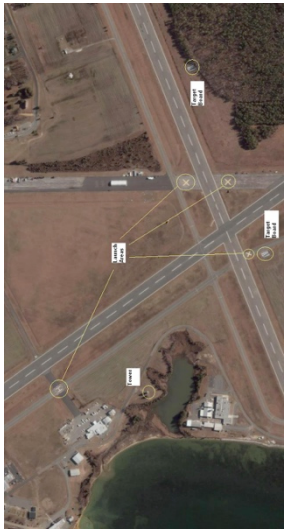

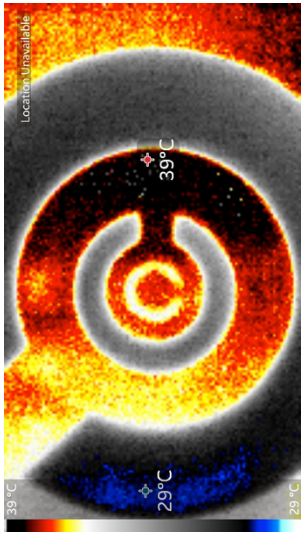

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Forms for Self (or Proctored) Evaluations

Safety | Capabilities | Proficiency

Airframe
- Impact Forces
- Lights and Sirens
- Prop Guards

Comms
- Lost Comms Behaviors
- Line of Sight Range
- Beyond Line of Sight
- Structure Penetration
- Interference

Energy
- Lost Power Behaviors
- Endurance Range
- Endurance Dwell

NIST National Institute of Standards and Technology U.S. Department of Commerce

Standard Test Methods For Response Robots
ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

Version: 2016.11
ASTM #Validating

Aerial System Capabilities, Maneuvering (Basic Skills)

Date: _____ Robot Make: _____

Facility: _____ Robot Model: _____

Location: _____ Robot Config: _____

Event / Sponsor: _____ Owner Organization: _____

Follow Lines – Fixed Orientation – Away

Follow Lines – Fixed Orientation – Toward

Follow Lines – Aligned

Follow Lines – Nose in Box

Follow Lines – Tail in Box

Operator Code | UAS Mode Auto. Man. | Pilot Mode Eyes On Eye Off | Environment Lit Dark | UAS Heading* UR DR NA | Wind Level 1 2 3 On Off | * UR – Up Range DR – Down Range NA – Not Applicable | Admin Pause OCU Reset Robot Fault

Start Time __:__ | End Time __:__ | Completed | Elapsed Time | Rate = Tasks / Min

Video File Naming Convention
EVENT-DAY#-MAKE-MODEL-CONFIG-MNV

Test Administrator | Organization

Sensors
- Visual Acuity
- Color Acuity
- Thermal Acuity
- System Latency
- Dynamic Range
- Camera Pointing

Maneuvering
- Pose Agilities
- Inspect Targets
- Center in Obstacles
- Land/Perch
- Deliver Payload

Awareness
- Point/Zoom Cameras
- Map Area (Stitched Images)

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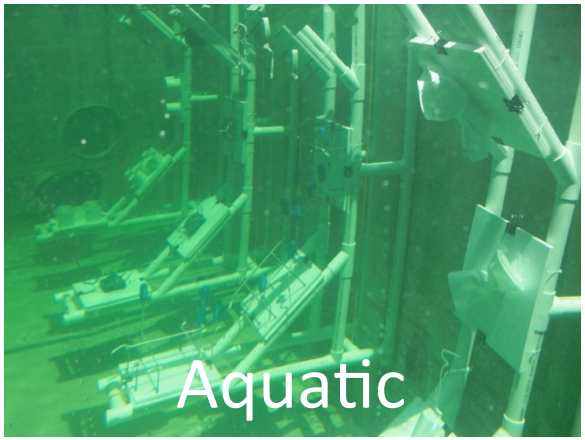

Adam Jacoff
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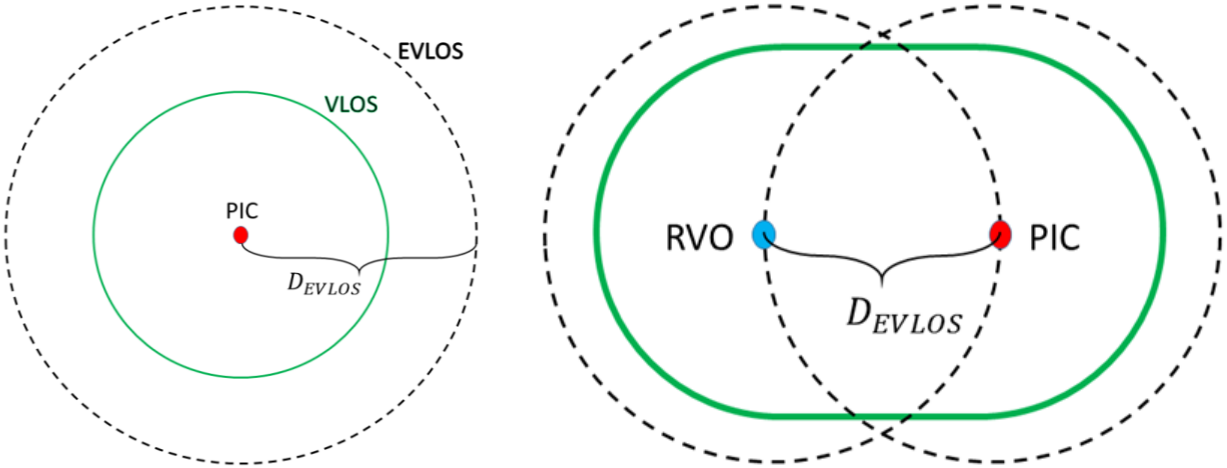
EVLOS Operational Requirements

Ally Ferguson (PrecisionHawk), Matt DeGarmo (MITRE)

Extended Visual Line of Sight



Definition from WK52059:

3.1.6 extended Visual Line of Sight (EVLOS) —operation when the sUA cannot be seen by the individuals responsible for see-and-avoid with unaided (other than spectacles/contacts lenses or sunglasses or both) vision but where the location of the sUA is known through technological means.

NOTE 3—Either the RPIC or, alternatively, the VO: can use said technological means for determining the location of the sUA to determine its movement relative to intruding aircraft, obstacles, or terrain; observe the airspace for other air traffic or hazards; and determine whether the sUA endangers life or property or both. To further clarify, technology means can be used to determine the position of the sUAS but the RPIC or the VO must be able to see the area the sUAS is known to be in so as to execute the required see-and-avoid function.

PRECISIONHAWK

Safety Case

- PrecisionHawk constructed an Operational Risk Assessment based on the Phase II results. This resulted in a commercial waiver to VLOS requirement of Part 107.
- Some key mitigations based on the research:

+ **Sun Position:** Altitude of sun > 45^{o} above the horizon
+ **VFR meteorological conditions**
+ **Visual angle** < 5 degrees in quadrant centered on UA location
+ **PIC location** free of significant noise pollution (i.e. generators, farm equipment, trucks)
+ **PIC qualifications:**
    - Meets all Part 107 requirements
    - 15-20 hours VLOS flight time in desired operating environment on the specific UAS (both aircraft and GCS).
    - In-field flight training in EVLOS operation from an EVLOS-experienced operator (~2 or 3 short sorties and 2 or 3 longer ones is enough to establish the appropriate strategies necessary for EVLOS flight)

PRECISIONHAWK