FlySense

Standards and Regulations

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ASTM F3002

Standard for Command and Control System for Unmanned Aircraft

Motivation and Applicability

- **Need a general standard for flying unmanned aerial vehicles**
  - What happens when there is a lost connection?
  - What happens when the aerial vehicle flies somewhere it is not supposed to go?

- **ASTM 30002 attempts to address these questions and enforces a standard for all unmanned aerial vehicles under 25kg ("small" Unmanned Aerial Systems)**

Terminology and Abbreviations

Unmanned Aerial System (UAS):
Flight hardware and control systems for fully functional flying vehicle under 25kg

Ground Control Station (GCS):

Location with equipment for human control of the UAS

Command and control links (C2):

Safety critical RF link between GCS and unmanned aircraft

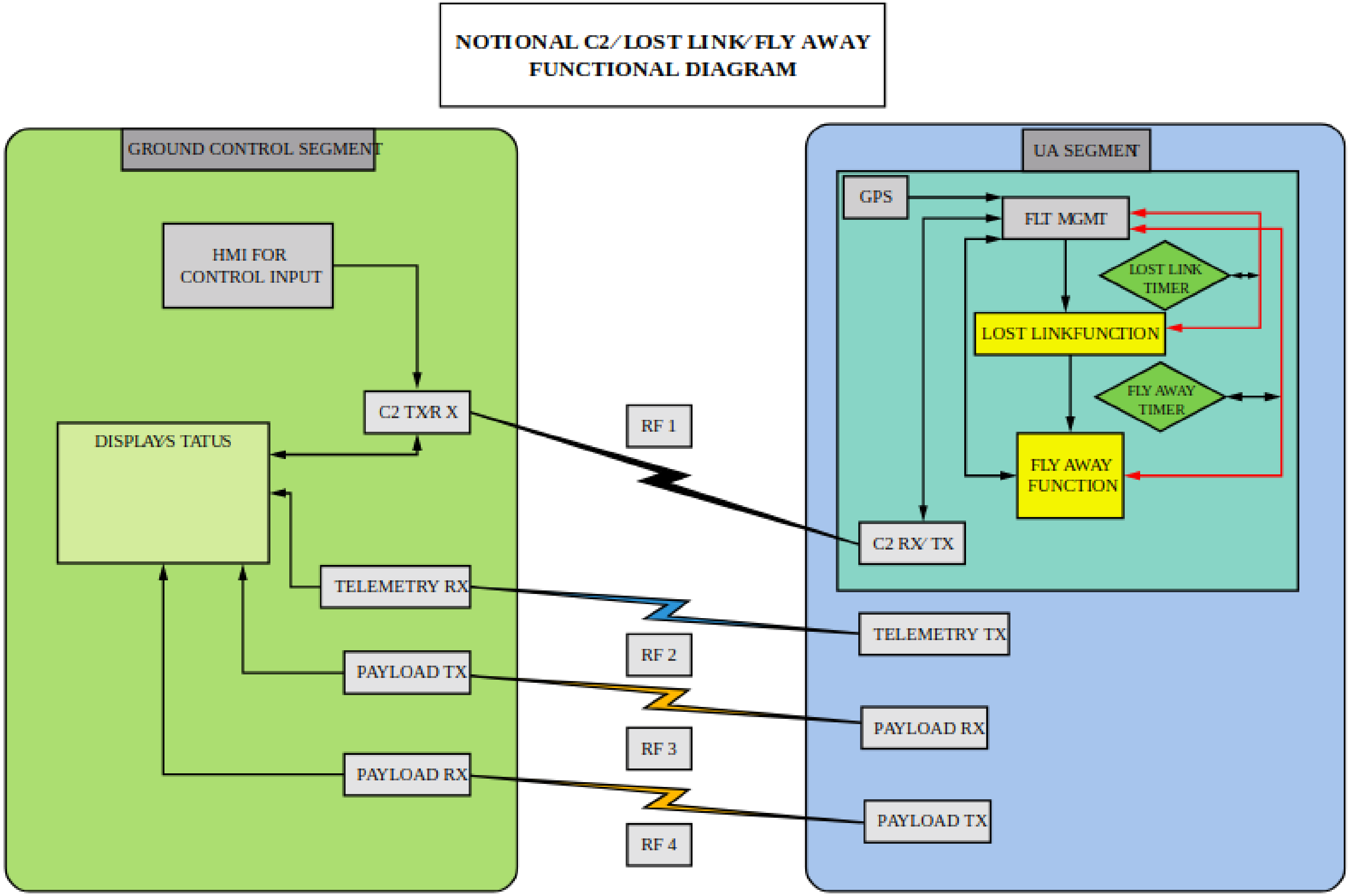
Lost Link:

Condition where the pilot can no longer control the UAS due to loss, interruption, or degradation of signal

Fly Away:

Unintended flight outside of operational area due to failure of control and/or onboard system

Functional Architecture



ASTM F3002: STANDARD FOR COMMAND AND CONTROL SYSTEM FOR UNMANNED AIRCRAFT

General Regulations

- **System must minimize Radio-Frequency interference to ensure robustness of the controller**

- **Control equipment must be protected from environmental conditions**

- **Control equipment and communication must we rigidly attached to respective hardware and have a robust construction**

THAT SHOULD TAKE CARE OF MY ELECTROMAGNETIC RADIATION PROBLEM!!
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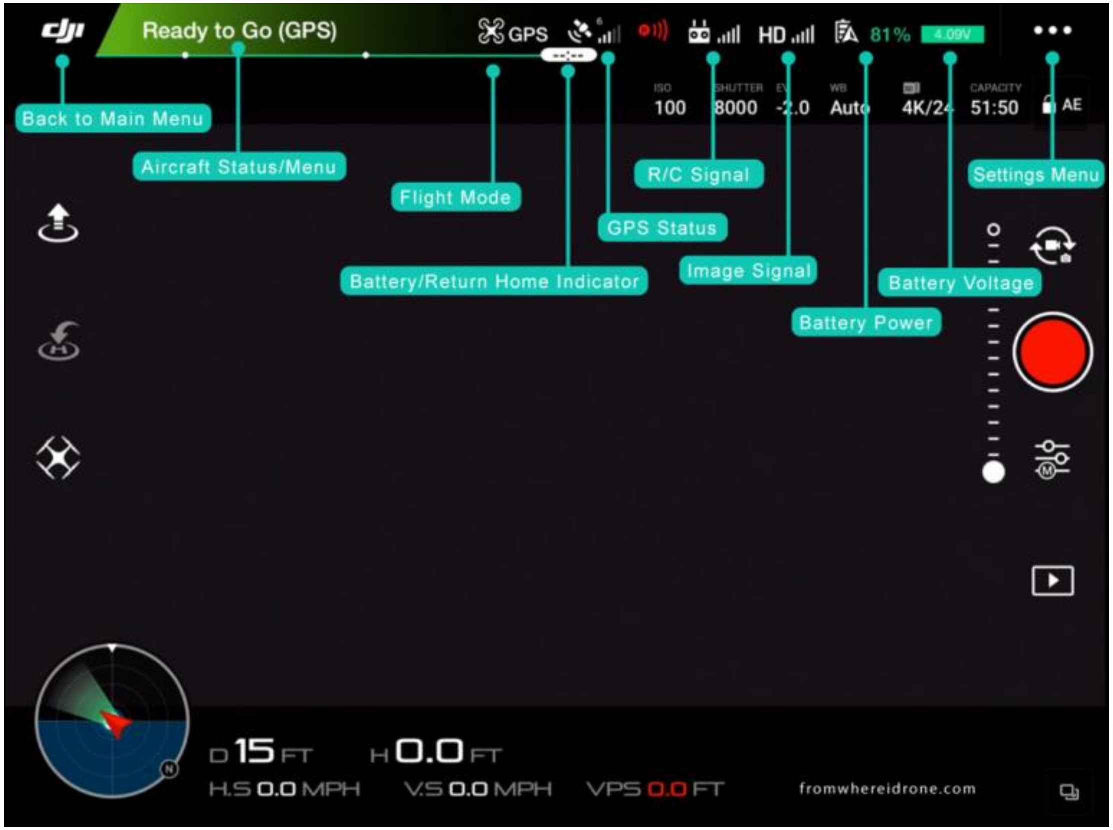
Ground Control Station Requirements

- **Ground Control Station must give the operator knowledge of the communications status**
- **Ground Control Station must provide telemetry if the aerial vehicle is able to broadcast it**



ASTM F3002: STANDARD FOR COMMAND AND CONTROL SYSTEM FOR UNMANNED AIRCRAFT

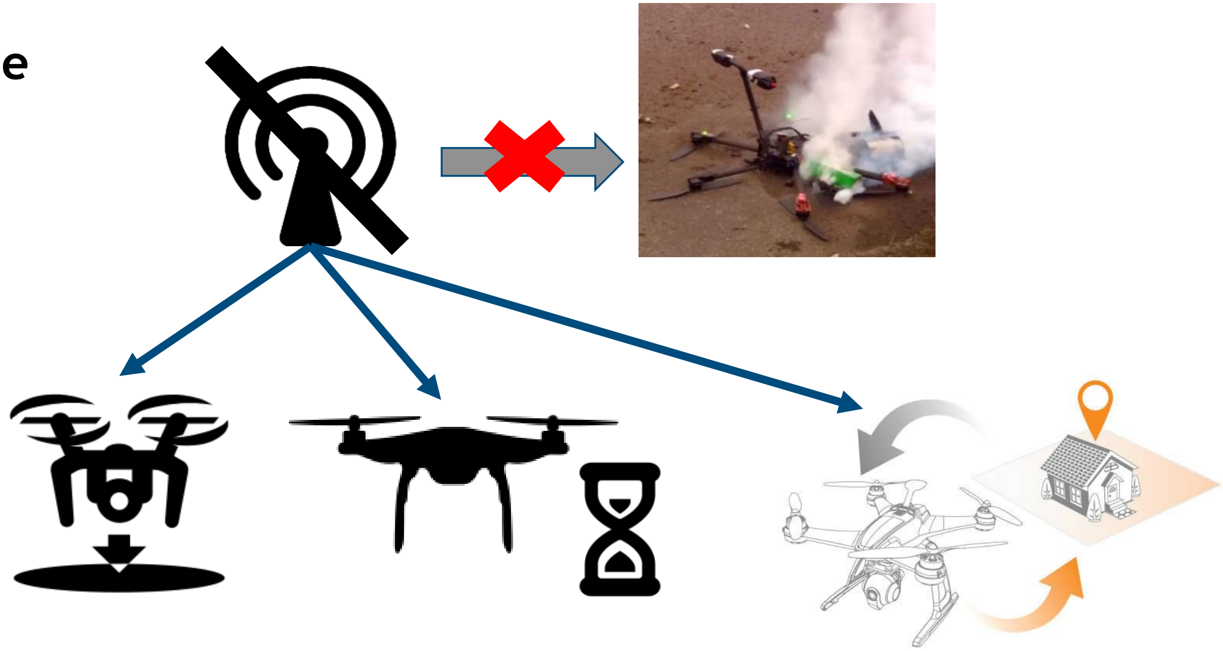
Unmanned Aircraft Requirements

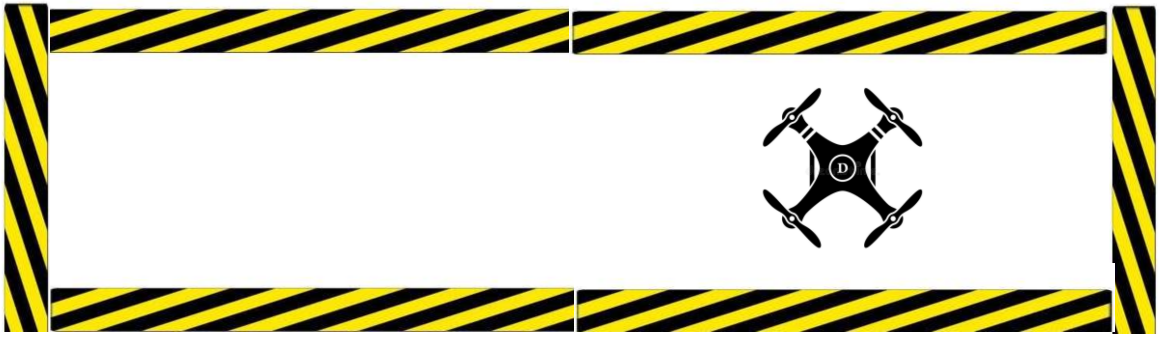
- **Lost link action has to be able to execute even after the loss of communication**

- **Lost Link can’t make the aerial system fail**

- **With loss of communication, aerial system must**
  - Land safely and terminate flight, or
  - Return to home position, or
  - Wait for a time before executing one of the previous options

- **UAS has to be able to operate in a confined area**





Fly Away Requirements

- **Fly away prevention must still work even if communication fails**

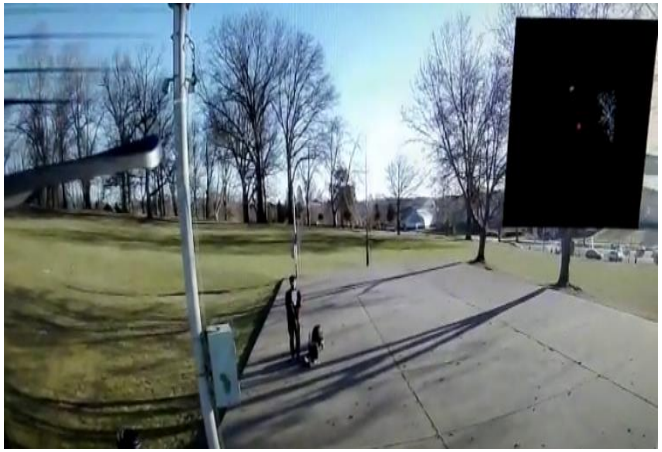
ASTM F3002: STANDARD FOR COMMAND AND CONTROL SYSTEM FOR UNMANNED AIRCRAFT

What it means for FlySense

- **Equipment we use**
  - DJI follows these guidelines as a manufacturer – our system is safety ensured

- **Modifications we make to the software system must comply with the standard**
  - As we make modifications to the system, we can’t override the existing safety and communication architecture

- **How FlySense follows the standard**
  - Take-off only after thorough check with the DJI SDK app
  - One operator is always in-charge of ensuring proper communication
  - Pilot command override for obstacle avoidance implemented using the permitted DJI SDK ‘function mode’

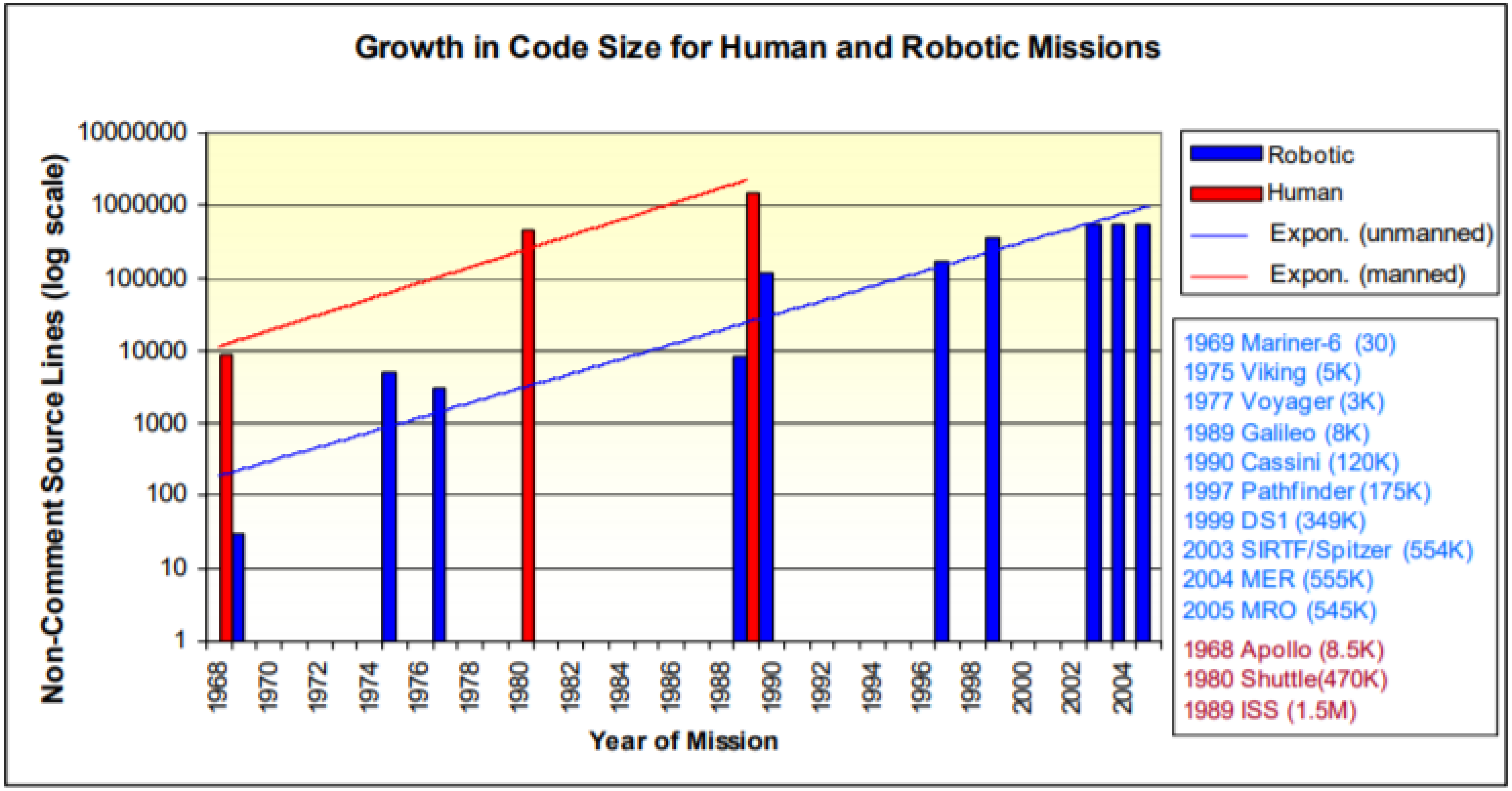


DO-178C

Software Considerations in Airborne Systems and Equipment Certification

DO 178C: WHY WAS IT DEVELOPED

The rapid increase in the use of software in airborne systems resulted in the need for industry-accepted guidance for satisfying airworthiness requirements



History of flight software growth in human and robotic missions

It provides guidelines for the production of software for airborne systems

- **It is the primary document by which the certification authorities such as FAA, EASA and Transport Canada approve all commercial software-based aerospace systems.**

- **A means of showing compliance with the applicable airworthiness regulations for the software aspects of airborne systems and equipment certification.**

Aérospatiale/BAC Concorde is a British-French turbojet

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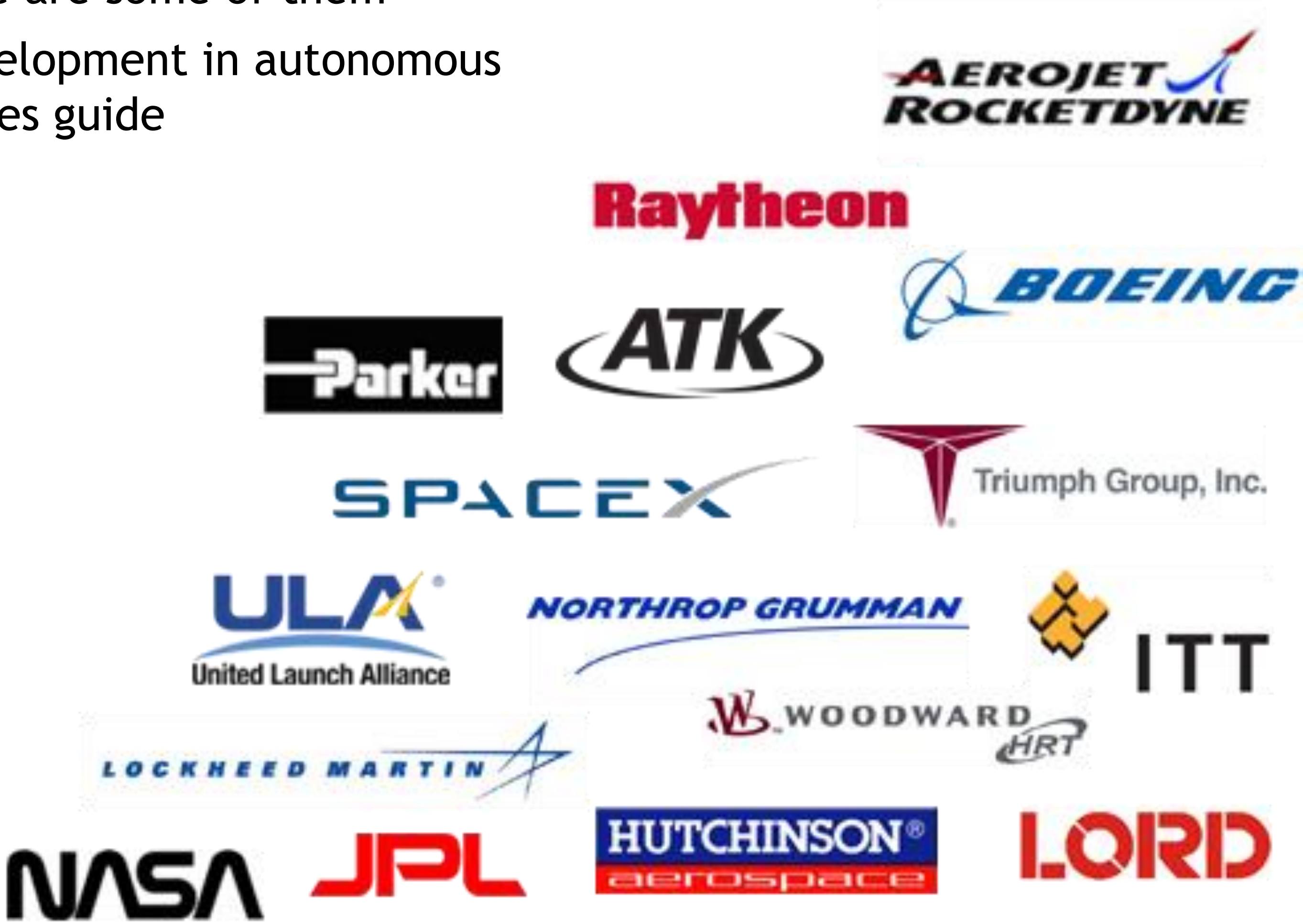
DO 178C:WHO USES THIS STANDARD

Aerospace companies following DO-178 guidelines

- The list is huge, these are some of them
- Also for software development in autonomous cars as a best-practices guide

FlySense

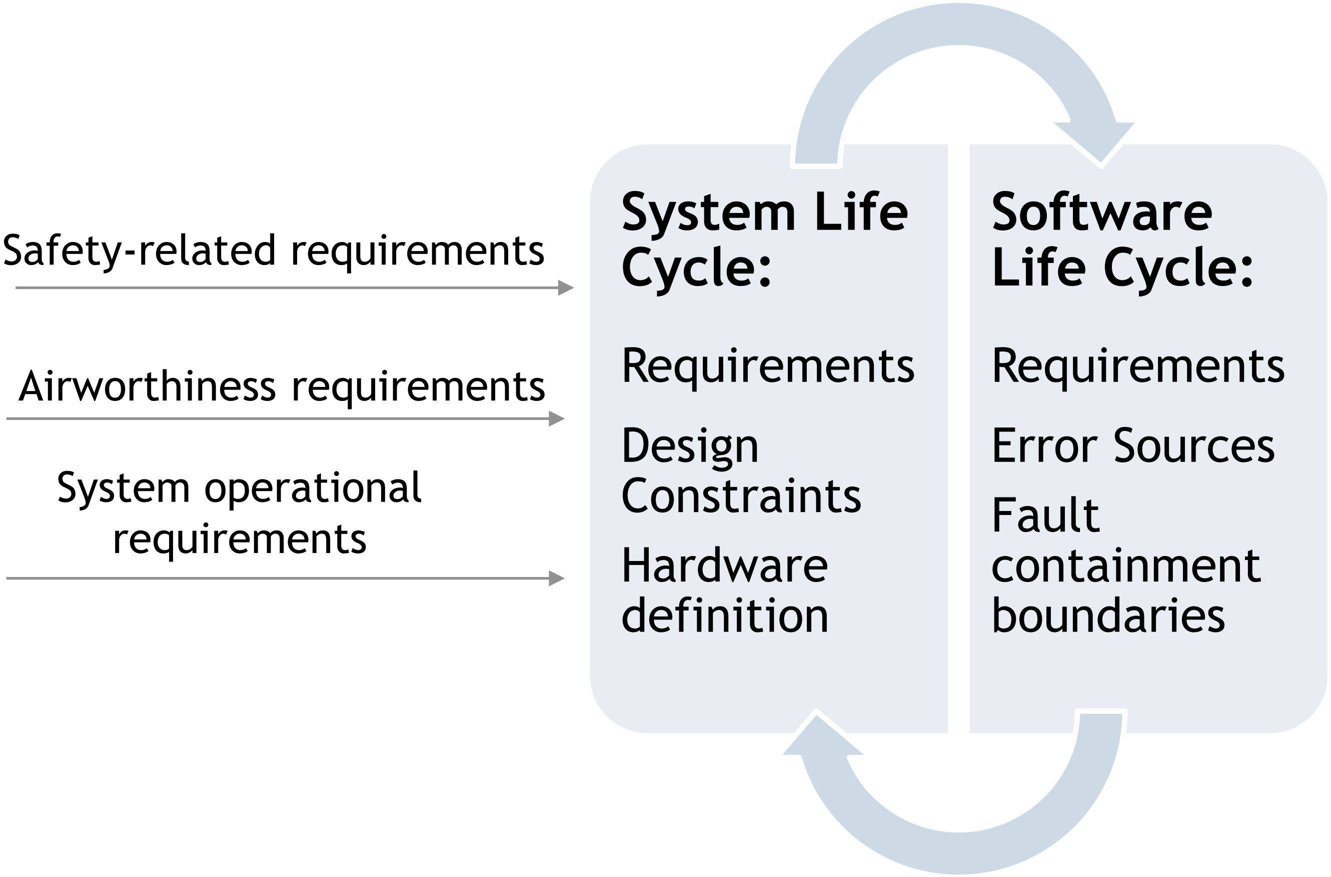


DO 178C: GUIDELINES

What do the guidelines prescribe?

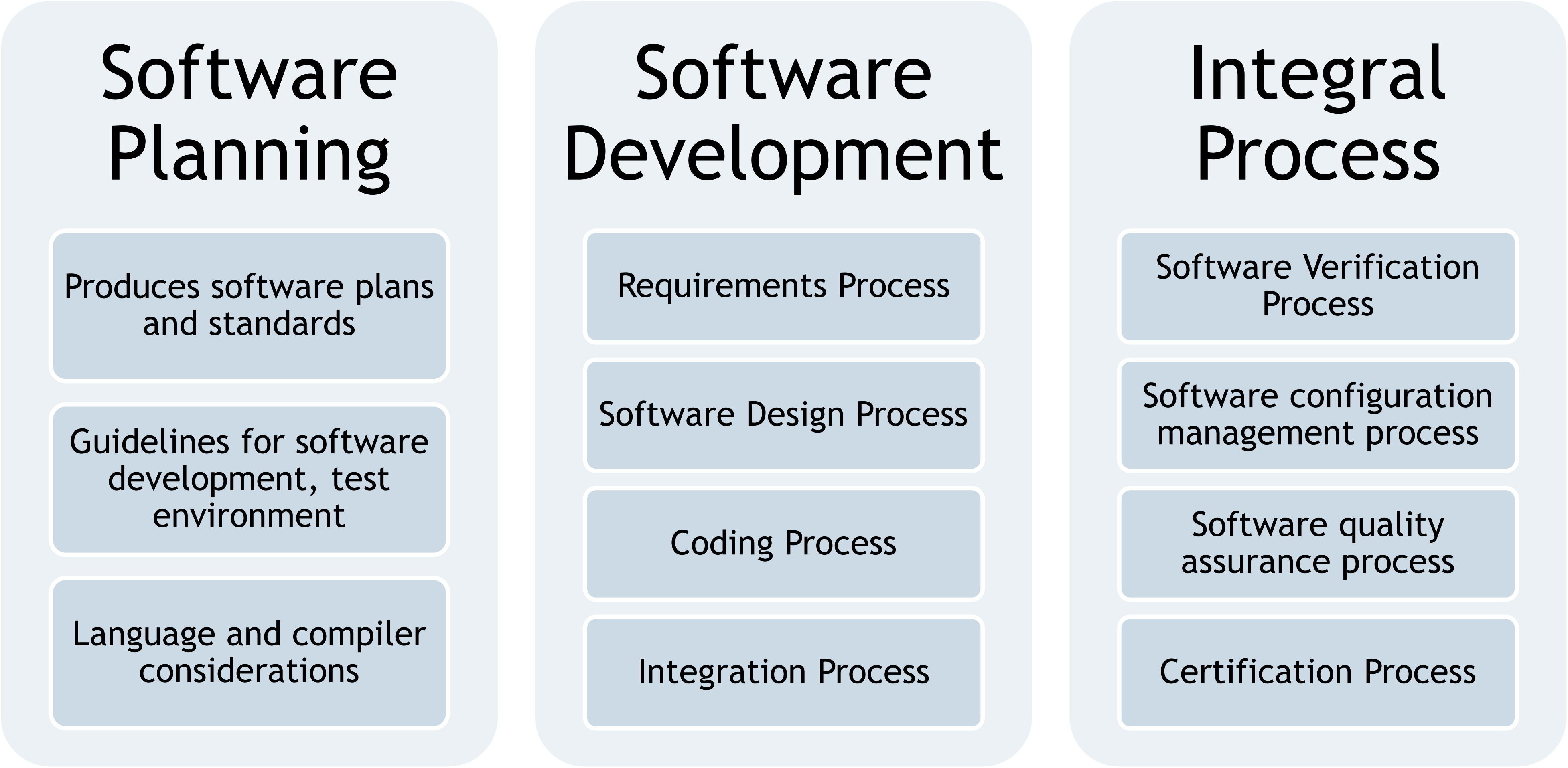
- Objectives for software life cycle processes
- What activities and procedures to follow to achieve those objectives
- What documentation to produce as evidence that the objectives have been satisfied
- Certification issues are discussed only in relation to software life cycle. The operational aspects of the resulting software are not discussed in the document

System <-> Software life cycle


Safety-related requirements
Airworthiness requirements
System operational requirements
System Life Cycle:
Requirements
Design Constraints
Hardware definition
Software Life Cycle:
Requirements
Error Sources
Fault containment boundaries

DO-178C: SOFTWARE LIFE CYCLE PROCESS

Following a predefined process ensures safe and bug free software



Software Planning

- Produces software plans and standards
- Guidelines for software development, test environment
- Language and compiler considerations

Software Development

- Requirements Process
- Software Design Process
- Coding Process
- Integration Process

Integral Process

- Software Verification Process
- Software configuration management process
- Software quality assurance process
- Certification Process

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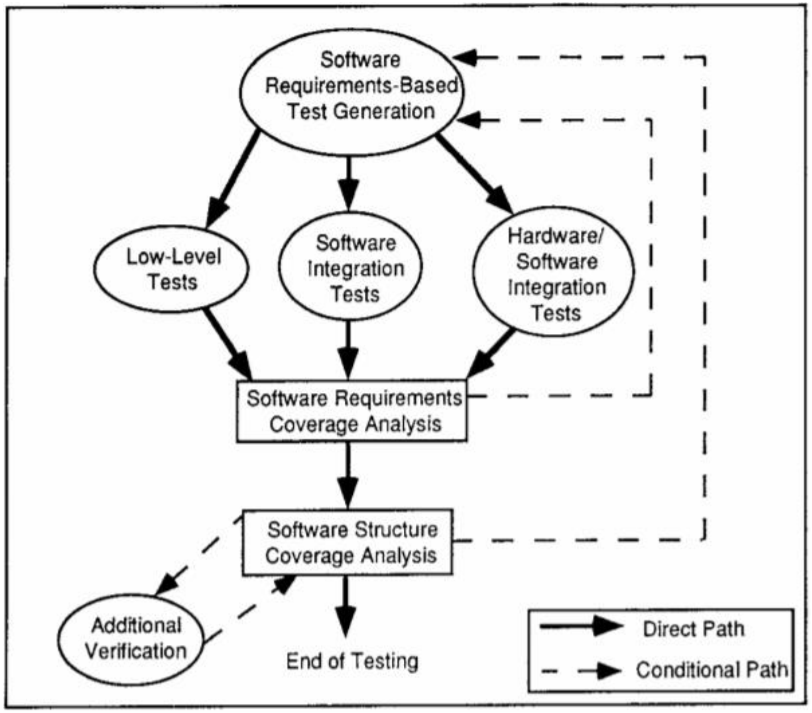
DO-178C: SOFTWARE VERIFICATION

The general objectives of the software verification process are to verify that:

- The system requirements have been developed into software high-level requirements
- The high-level requirements have been developed into software architecture and low-level requirements
- The software architecture and low-level requirements have been developed into Source Code
- The Executable Object Code satisfies the software requirements.
- The means used to satisfy these objectives are technically correct and complete for the software level.

Software testing process


Software Requirements-Based Test Generation
Low-Level Tests
Software Integration Tests
Hardware/ Software Integration Tests
Software Requirements Coverage Analysis
Software Structure Coverage Analysis
Additional Verification
End of Testing
Direct Path
Conditional Path

Goal: Traceability and Correctness

DO-178C: FAILURE CONDITION AND SOFTWARE LEVEL

Higher level implies higher level of effort required to show compliance with certification requirements

Failure Categories	Software Level	Description
Catastrophic	Level A	Prevent continued safe flight and landing
Hazardous/Severe -Major	Level B	Failure conditions which would reduce the capability of the aircraft or potential fatal injuries
Major	Level C	A significant reduction in safety margins or functional capabilities or discomfort to occupants
Minor	Level D	Would not significantly reduce aircraft safety, and which would involve crew actions that are well within their capabilities
No Effect	Level E	Failure conditions which do not affect the operational capability

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How does it apply to flysense?

- **Information provided to the pilot has to be accurate, otherwise it can lead to problems**
- **Software has to work in all possible conditions without failure**
- **Pilot override feature is safety critical and should be developed following the guidelines of design, verification and testing**
- **To be DO-178C compliant, we would have to:**
  - Write High-level and low-level software requirements
  - Develop software development plan
  - Ensure traceability of each requirement to the code
  - Establish verification strategies
  - Generate artifacts that prove compliance