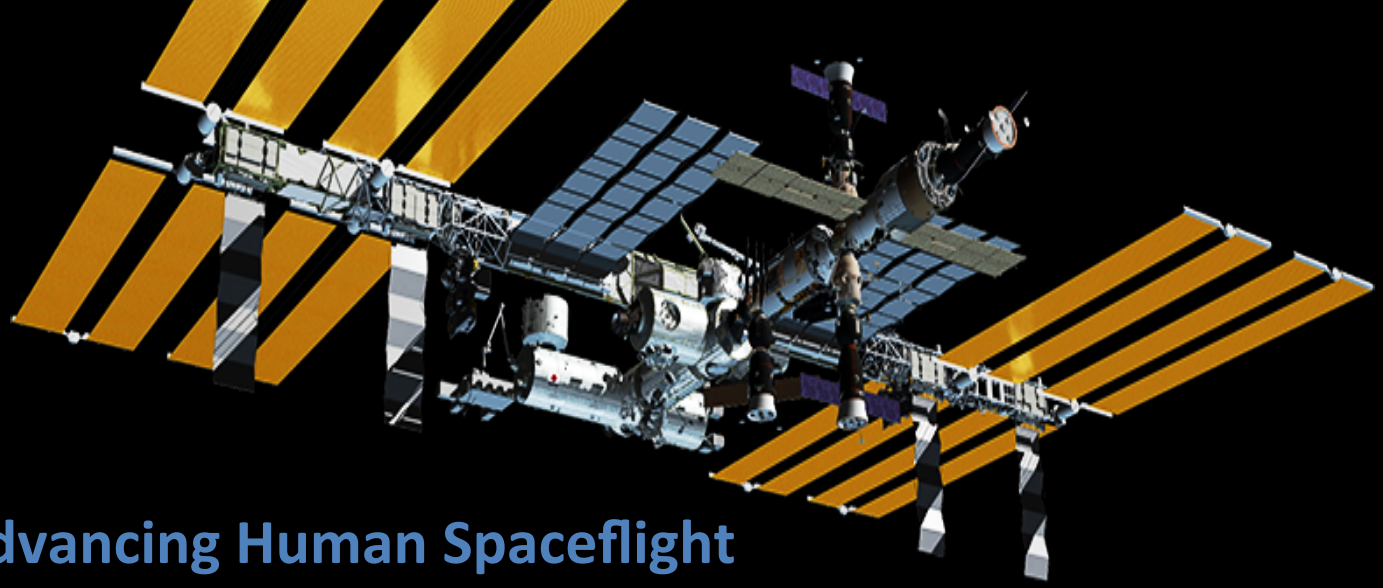
National Aeronautics and
Space Administration

Commercial Crew Program (CCP) Status

Philip McAlister / NAC HEO Subcommittee / July 2016

Agenda

- Commercial Crew Program (CCP) Highlights
- Major Contract Milestone Status
- Space Act Agreement Status
- CCP Top Program Risks
- Boeing Summary
- SpaceX Summary
- Budget
- Conclusion



Advancing Human Spaceflight

The vision of commercial human spaceflight to low-Earth orbit is a robust, vibrant enterprise with many providers and a wide range of private and public users.
A successful human space transportation system will strengthen the International Space Station Program, allow NASA to focus on deep-space exploration, potentially reduce the cost of human access to space and significantly contribute to the national economy.

CCP Public Purpose

Support the development of non-NASA markets for commercial human transportation services to and from low-Earth orbit.

CCP NASA Purpose

Safe transport of NASA and NASA-sponsored astronauts to and from the station.

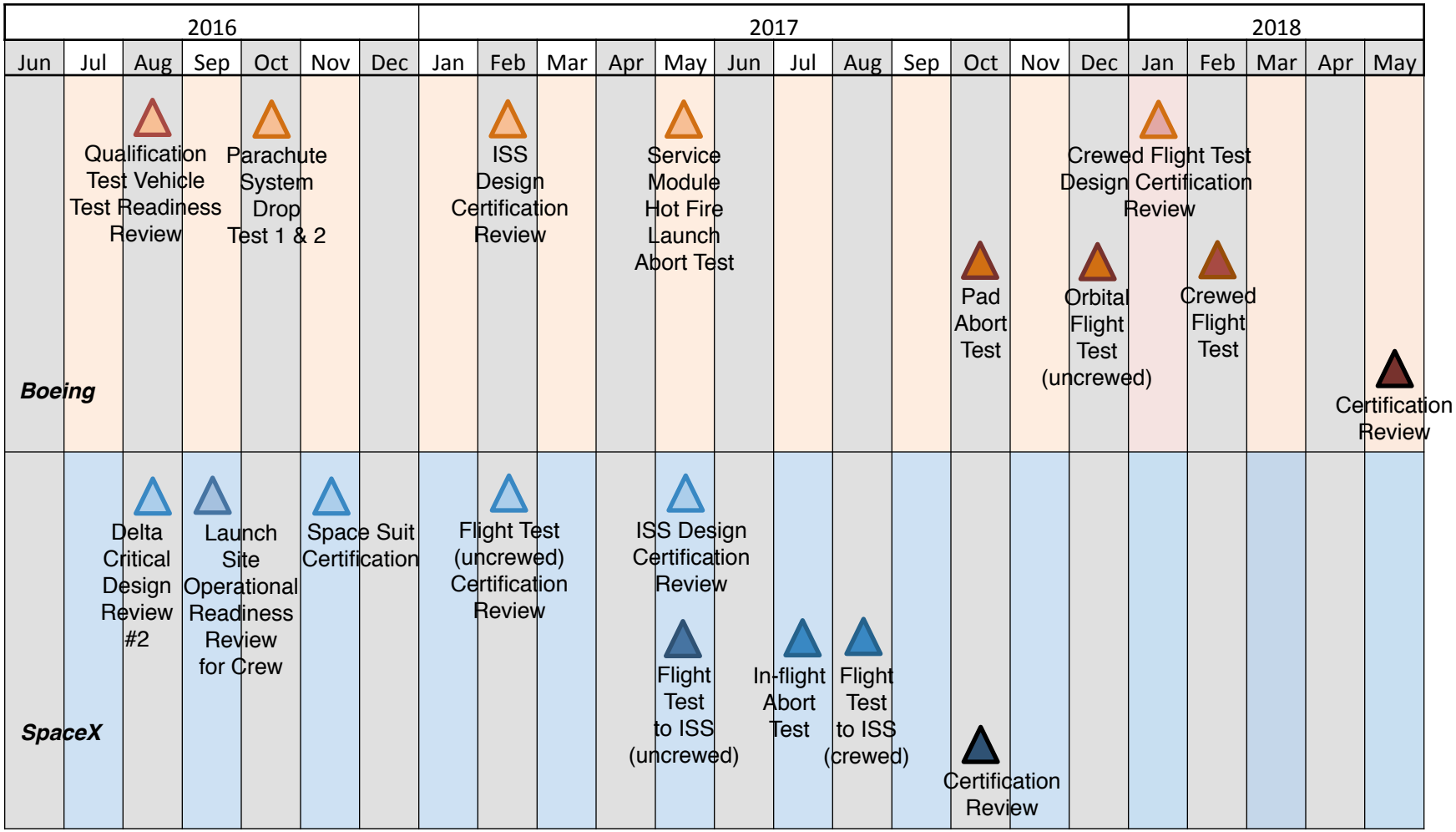
Highlights

CCP has made significant progress over the last quarter, notably:

- **Continue to burn down key products with the providers**
  - Over 90% of the alternate standards are completed
  - Over 60% of the variances are completed
  - Over 60% of the Phase 2 hazard reports are completed

- **Eight CCP missions now in process:**
  - For SpaceX:
    - Uncrewed and crewed test missions
    - PCM-1 awarded November 2015; Completed one milestone to date
    - PCM-2 award expected in August 2016
  - For Boeing:
    - Uncrewed and crewed test missions
    - PCM-1 awarded May 2015; Completed three milestones to date
    - PCM-2 awarded in December 2015; Completed one milestone to date

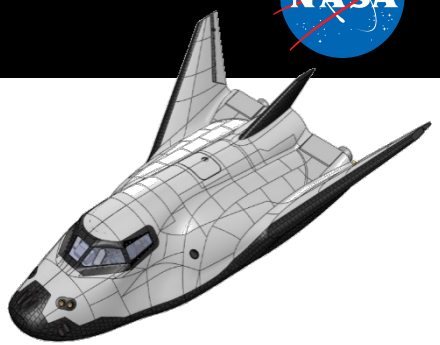
CCP Major Partner Milestones



Blue Origin

- **Entered into a new unfunded Space Act Agreement, April 2016**
  - Purpose: Facilitate progress maturing the design and development of an orbital commercial human space transportation system
  - Scope: Space Vehicle, Reusable Booster System, Launch Vehicle and Ground and Mission Operations
- **Accomplishments**
  - Completed first Technical Interchange Meeting (TIM)
  - NASA provided Blue Origin an accelerometer to be flown on its last flight
    - Flight data to be used jointly by NASA and Blue Origin
- **Look Ahead**
  - Corrosion Control TIM; summer 2016

Sierra Nevada Corporation



- **Space Act Agreement extended to June 2017**
- **Approach & Landing Test 2 – December 2016 flight test**
  - Full scale Dream Chaser Engineering Test Article
  - Unpowered approach & landing test
  - Collect subsonic aerodynamic data to validate wind tunnel and CFD aero results
  - Validation of low-speed aerodynamic flying qualities – stability and control
  - Validate subsonic orbital vehicle flight software and GN&C functionality
  - Demonstrate the fault tolerant flight computer performance
- **Key Activities**
  - Avionics racks installed, all harnesses installed and terminated
  - Bonded “ALL” major Thermal Protection System (TPS) pieces to vehicle and aeroshells
  - Flight Like TPS installed on nose skid
  - Installed side/aft and lower aft aeroshells for flight
  - Completed strain gage calibrations
  - Completed hydraulic system modifications/installation
  - Avionics/Comm checkouts underway

CCP Top Programmatic Risks 6/28/16

Program Control & Integration (PC&I)

- Requirement Changes (PCI-2015-3)

Systems Engineering & Integration (SE&I)

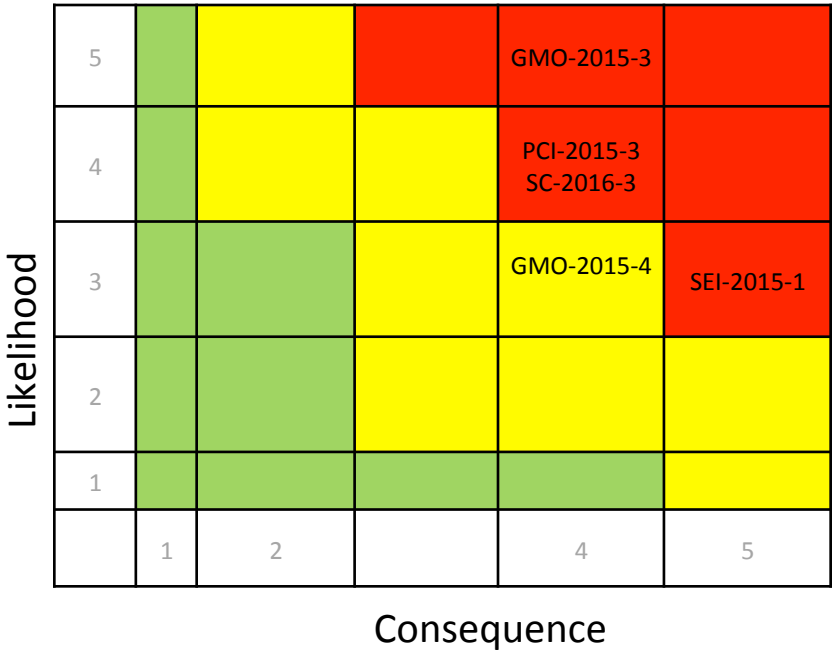
- Ability to Close the LOC Gap (SEI-2015-1)

Ground & Mission Operations (G&MO)

- Search and Rescue Posture (GMO-2015-3)
- DoD Search & Rescue Training Schedule (GMO-2015-4)

Spacecraft

- Ammonia Emergency Response (SC-2016-3)



Boeing Architecture Description

Spacecraft Segment

Simplicity of design with high maturity through use of existing technologies within Boeing and from our key suppliers such as Aerojet Rocketdyne and General Dynamics

- Crew Module
- Service Module
- Flight Software

Launch Segment

Mature design through use of heritage design, production, and operations from our key supplier ULA

- Launch Vehicle
- Launch Control Complex
- Spacecraft / LV Integration
- Launch Pad
- Pad Test and Checkout
- Emergency Detection System

Ground and Operations Segment

Mature design and processes through use of proven Boeing production techniques

- Cargo Integration
- Landing and Recovery
- Network Services
- Assembly, Integration and Test Facility
- Landing Site Facilities

Mature mission operations through use of heritage mission support from our key supplier JSC/Flight Operations Directorate (FOD)

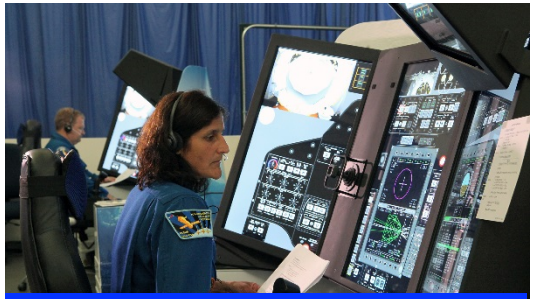
- Crew Training
- Mission Planning
- Mission Operations
- Mission Control Center
- Training Systems

Boeing Accomplishments

- **Design**
  - CST-100 Starliner spacecraft design in firm configuration
  - Design solution selected to address non-linear aerodynamic acoustics and loads – in final stages of wind tunnel testing
- **Demonstration & Test**
  - Water landing qualification tests at NASA Langley complete
  - Part-Task Trainers acceptance testing complete and delivered
  - Parachute qualification testing beginning in August
- **Production & Qualification**
  - Shipped Service Module to California for structural testing
  - Spacecraft 1 docking hatch, upper and lower domes delivered
  - Approximately 40% of components will be in qualification testing within the next 60 days
- **Facility Preparations**
  - Ribbon cutting on Space, Training, Analysis and Review (STAR) Facility
  - Commercial Crew and Cargo Processing Facility (C3PF) at NASA Kennedy getting fleshed out

STAR Facility Open

C3PF Hazardous Processing Facility



Crew Part Task Trainers

SpaceX System Description

- **Spacecraft Segment (Dragon)**
  - Crew Dragon
  - Trunk
  - Launch Abort System (internally integrated in Dragon)
- **Launch Segment (Falcon 9)**
  - Full thrust Merlin engines
  - Densified propellants (chilled LOX & RP-1)
  - Common First stage w/Falcon Heavy design
  - Autonomous Flight Termination System
  - Landing legs (stowed in ascent)
  - Stage separation system
- **Ground and Operation Segment**
  - Launch Operations System
    - Launch Pad (LC39A), Launch Pad facility, Ground SW, & Launch Control Center
  - Mission Operation System
    - MCC (Hawthorne) Crew Ops, Training & Sim, & Recovery

Crew Dragon Vehicle

Falcon 9

Mission Control
Hawthorne, CA

Launch Control
Cape Canaveral, FL

LC-39A
Kennedy Space Center, FL

SpaceX Accomplishments

- **Design**
  - Completed dCDR2 Spacesuit & Trunk TIMs
    - Space suit is currently in fabrication
  - Multiple dCDR2 packages delivered and reviewed
  - Approximately 50% launch site design reviews completed for crew interfaces to LC-39A
- **Demonstration & Test**
  - Completed 6 full thrust flights with load & go operations with densified propellants
  - Completed all 3 demonstration flights needed for Range approval to use Automated Flight Termination System
- **Production & Qualification**
  - 4 Dragon pressure vessel weldments in production
  - Dragon batteries and components progressing through testing
  - Multiple components entering qualification phase and on track for testing

Budget

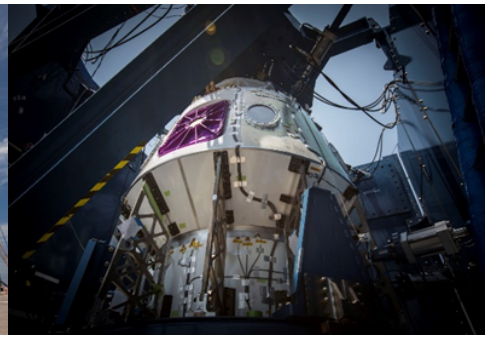
($ in millions)	FY 2016 *	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
FY 2017 President's Budget	1,243.8	1,184.8	731.9	173.1	35.8	36.3

** FY 2016 reflects the amounts in the FY 2016 President's budget which were fully appropriated*

- CCP will continue to manage crew transportation services to ISS after partner vehicles are certified.
- First two Post Certification Missions will be funded by CCP.
- Additional Post Certification Missions are expected to be authorized at a nominal pace of two per year, funded by the Crew and Cargo Program.
- Critical that CCP receive full FY 2017 President's Budget Request to support planned milestones and certification to end sole reliance on Russia for U.S. crew transportation.

Summary

- **Boeing and SpaceX are advancing their design concepts**
  - Actively building and testing hardware to inform design
  - Engaging in meaningful insight with NASA
  - Addressing important design challenges
- **Both providers are providing increased insight opportunities for the NASA team**
- **CCP has robust and efficient processes for certification including addressing waivers and deviations**
- **In preparation for flight, there is significant work ahead**



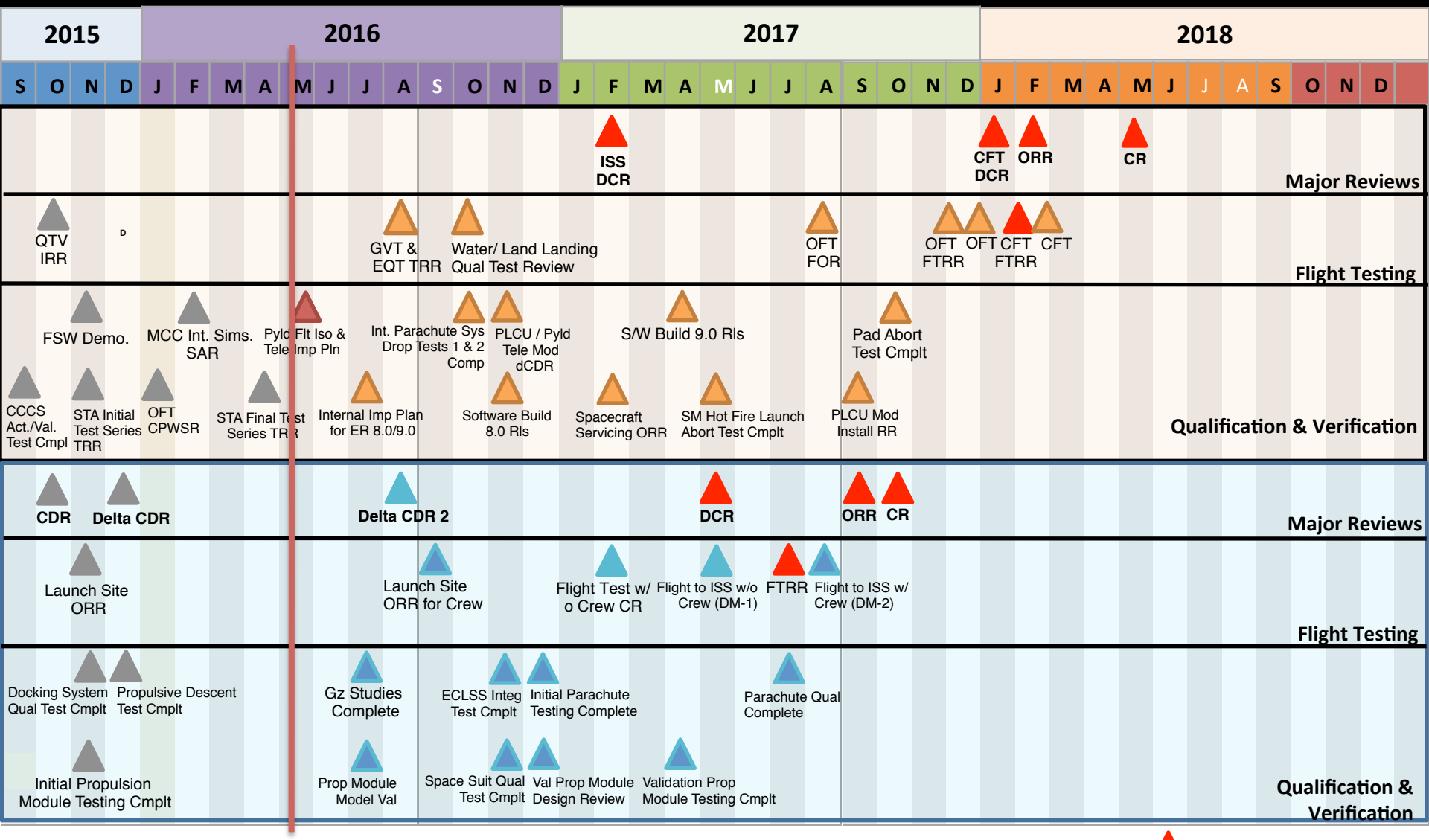
Acronym List

CCP	Commercial Crew Program
NAC	NASA Advisory Committee
HEO	Human Exploration and Operations
PCM	Post Certification Mission
ISS	International Space Station
TIM	Technical Interchange Meeting
CFD	Computational Fluid Dynamics
GN&C	Guidance, Navigation and Control
TPS	Thermal Protection System
PC&I	Program Control and Integration
SE&I	System Engineering and Integration
G&MO	Ground and Mission Operations
DoD	Department of Defense
ULA	United Launch Alliance
LV	Launch Vehicle
FOD	Flight Operations Directorate
JSC	Johnson Space Center
STAR	Space, Training, Analysis and Review
C3PF	Commercial Crew and Cargo Processing Facility
LOX	Liquid Oxygen
SW	Software
MCC	Mission Control Center
dCDR2	Delta Critical Design Review 2
FY	Fiscal Year
DCR	Design Certification Review

CFT	Crew Flight Test
ORR	Operational Readiness Review
CR	Certification Review
QTV	Qualification Test Vehicle
IRR	Integrated Readiness Review
GVT	Government Verification Test
EQT	Engineering Qualification Test
TRR	Test Readiness Review
OFT	Orbital Flight Test
FTRR	Flight Test Readiness Review
CCCS	CST-100 Checkout and Control System
FSW	Flight Software
STA	Structural Test Article
CPWSR	Configuration, Performance and Weight Status Report
SAR	System Acceptance Review
ER	Engineering Release
PLCU	Payload DC to DC Converter Unit
SM	Service Module
CDR	Critical Design Review
DM-1	Demo Mission 1
DM-2	Demo Mission 2
ECLSS	Environmental Control Life Support System

Back Up

CCtCap Combined Milestone Summary Official – FY16Q2



CCtCap CMS-Official May 20, 2016
Data Source: Boeing FY16Q2 / SpaceX FY16Q2

Required Milestone (RM)
Boeing Milestone
SpaceX Milestone.