



## **NATIONAL TRANSPORTATION SAFETY BOARD**

Office of Aviation Safety  
Washington, D.C. 20594

March 4, 2015

### **Attachment 24 – Flight and Test Reviews**

# **OPERATIONAL FACTORS**

**DCA15MA019**

The following information was provided by request to the NTSB from Scaled Composites.

## **Response - Reviews:**

Preparation for PF04 began immediately following PF03 which occurred on January 10<sup>th</sup> 2013 approximately 8.5months prior to PF04. The goals for PF04 morphed a couple of times driven by dependency on the rocket motor. PF04 was initially envisioned as a longer duration burn with the SNC HTPB hybrid. To this end, the vehicle was being configured with extra (b) (4) tanks in the wings (b) (4). This work was wrapping up in the early spring of 2014. However, due to continued issues with that path, work was ceased on that effort by June<sup>1</sup>.

The parallel Scaled Nylon fueled hybrid was made the primary path in May-June of 2014. This required repurposing the extra wing (b) (4) tanks for (b) (4) in addition to retrofitting, modifying and replacing portions of the (b) (4). Additional (b) (4) were also integrated. This modification cycle along with associated rocket motor development and qualification testing paced the program from May through PF04 in October of 2014.

Integration of the tanks was done in concert with other major mods to the airframe. In an effort to maintain test team proficiency, and as an effort to efficiently utilize the schedule, a strategic decision was made to perform a functional check flight of SS2 with the new modifications. Though much of the new (b) (4) was integrated, the system was flown inert (b) (4). An FRR was held specific to the structural (b) (4) other airframe mods. The GF029 FRR (Glide Flight 29 Flight Readiness Review) was held 7-17-2014.

## **GF029**

### **Major FRR topics:**

- Cabin interior mods to support new VG seat structure
- ...& associated avionics removal, reinstallation and functional testing
- New heated windscreen install
- Vehicle mods for tank integration (primarily structural interface of tanks)
- Other airframe mods to support change to Plastic Hybrid Motor
- Limitations while mated
- WK2 modifications/status pertaining to flight

### **Flight Objectives:**

- Pilot Proficiency
- Customer Pilot Flight Training

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<sup>1</sup> Tank integration was wrapping up and material was being gathered for an FRR focused on the addition of (b) (4) tanks. This FRR also would have covered qualification testing of the full duration HTPB motor. These efforts started and stalled out in mid-May.

- Functional check flight for mods above

Following GF029, the vehicle was down for approximately one month for the final integration of the (b) (4) systems and required functional testing. The intent was to use CF02 (Cold Flow - 02) as a graduation exercise to cycle the systems in flight by flowing nitrous and also functioning the (b) (4) systems, but without (b) (4) onboard. (b) (4) (b) (4) in the wing bottles. It was also flown with the PF04 flight crew as a dry run / proficiency opportunity. Because this was the first operation of the end to end rocket system in the new configuration a FRR was held. CF02 FRR took place on 8-12-2014.

## **CF02**

### **Major FRR topics:**

- Review of changes specific to (b) (4) and Nylon Rocket motor systems in SS2 (as they pertained to flowing Nitrogen<sup>2</sup>)
- WK2 modifications/status pertaining to flight

### **Flight Objectives:**

- Cold Flow
- PF04 crew dry run
- Pilot Proficiency

Following CF02, final modifications to the airframe were completed and procedures refined to implement hardware to address potential (b) (4) leaks. Lessons learned from CF02 were also incorporated. To surface potential issues as soon as possible the PF04 FRR was held early to insure that there was time to resolve any potential show stoppers. PF04 FRR took place on October 3<sup>rd</sup>, 2014 before the rocket motor qual testing was complete (discussed in a following section). As expected, there were many action items (>50) generated in this review due to the complexity of the newly integrated rocket systems.<sup>3</sup>

## **PF04 FRR**

### **Major FRR topics:**

<sup>2</sup> NOTE: because the system would flow an inert gas there were several issues not discussed in this review. A major goal of this flight was to collect data on leak rates of components in the system in the actual flight environment. This data would directly influence next steps as it pertained to potential valve leaks and (b) (4) safety issues which would be addressed in PF04 FRR's to follow.

<sup>3</sup> As compared to a "typical" FRR.

- Review of changes specific to (b) (4) and Nylon Rocket motor systems in SS2
- Significant time was allocated for discussion of CONOPS for both ground and flight with (b) (4)
- Significant discussion of (b) (4) leak mitigations and testing
- Discussion of SS2 loads. This was first time we hinted we might delay due to lingering issues on this topic.
- WK2 modifications/status pertaining to flight

### **GF030**

Glide flight 30 didn't have significant airframe modifications and wasn't an envelope expansion flight. Therefore, no FRR was held. It is mentioned here because Scaled used it as a proficiency opportunity to keep the test team and crews sharp as we dealt with a longer than expected delay in the buildup to PF04. GF030 took place on October 7<sup>th</sup>, 2014.

Around the PF04 FRR, program management made the decision that we would not hit the desired timeline for PF04. In addition to all of the rocket motor upgrades, the main schedule driver was detailed analysis of SS2 for loads growth. The customer was made aware of the schedule change. They then requested a detailed, open-ended review of the whole program to look for other potential schedule delays. Scaled Management put together a "Town hall" meeting to meet the request. The Town Hall was similar to the FRR in that it involved not only the key players from the T1b program and the TSC customer, but like FRR it pulled in outside subject matter experts from within Scaled. This meeting covered all topics some pertaining to T1b operations and some pertaining to future TSC topics. Actions from this review that were immediately actionable (for T1b – 7 total) were captured in the standard T1b actions tracking spreadsheet. They were marked as appropriate to be resolved and some were in fact addressed along with other PF04 FRR actions prior to flight.

### **T1b Town Hall Meeting – October 22<sup>nd</sup>, 2014**

#### **Major topics:**

- Misc. overall program brainstorming discussion to unearth items that could delay Q4-2014 schedule
- 25 actions taken – 7 folded into FRR actions for near term resolution

Tests critical to PF04 were the rocket qualification tests. Prior to every new series of flights with a rocket motor Scaled performs a "qualification" hot fire series on the ground. For the series of flight tests starting with PF04, the key variables for the rocket motor consumables (Nitrous, (b) (4)) were enveloped and the repeatability of the system was demonstrated. It was Scaled policy to hold a Test Readiness Review (TRR – Ground test equivalent of an FRR) for

every ground hot fire. The following is a quick summary for the TRR's (Test readiness reviews) and tests that comprised the rocket motor test program in preparation for PF04.

### **Rocket Motor Qualification Firings & TRR's<sup>4</sup>**

- **Plastic Motor 21 TRR, 9-18-2014**
- **Qual 1 – PM21, 9-22-2014**
- **PM-22 TRR, 9-30-2014**
- **Qual 2 – PM22, 10-2-2014**
- **PM-23 TRR, 10-8-2014**
- **Qual 3 - PM23, 10-10-2014**

### **Major topics:**

- Manufacturing/ structural consistency
- Repeatability of motor performance
- Adherence to qual pass/fail criteria

A final Delta PF04 FRR was held as a clean-up review following the rocket motor qualification effort, and completion of the majority of the open action items from the PF04 FRR. The Delta FRR was held on October 27<sup>th</sup>, 2014.

### **PF04 Delta FRR**

### **Major FRR topics:**

- Rocket motor qual test results & status of PF04 Motor
- Resolution of all action items from PF04 FRR (mostly (b) (4) related)
- Specifics of PF04 flight with final RM systems
- Discussion of PF04 with reference to historical performance (to scope risk of envelope expansion)
- Discussion of analysis pertaining to SS2 loads growth (retiring this issue)
- WK2 modifications/status pertaining to flight

### **Flight Objectives:**

- New motor checkout
- Nozzle scarf angle verification
- Breach detection system evaluation
- Further aft CG through PF envelope

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<sup>4</sup> Attendees to rocket TRR's included mostly rocket team, T1b program and Scaled Management. Although not required, on occasion some of the flight crew members or other T1b participants would participate.. Regardless, it is included here for completeness.

- Re-clear up to Mach 1.4 at 10 Alpha
- Expand 1.4-1.8 Mach at 10-5 Alpha
- Expand 1.8-2.0 Mach at 3-5 Alpha
- Flutter expansion Mach 1.4-2.0
- Roll boost expansion Mach 1.4-2.0
- Inertial performance > ITAR limits
- RCS performance evaluation – 3 axis
- Feather extension < 20 keas
- Feather > Mach 1.1
- Stability, trim, drag, g max 1.6
- Plume expansion verification
- Directional VHF antenna system verification
- Trim schedule verification/evaluation
- Small GTOW increase for WK2

Typically, Scaled held an Executive FRR with key members of the program, Scaled & TSC/VG management, flight crews, and FRR board members prior to the test flight after major FRR action items were resolved. Scaled also invited the FAA (AST) to these reviews.

#### **PF04 Executive FRR – October 29<sup>th</sup>, 2014**

##### **Major FRR topics**

- Same as PF04 Delta FRR

##### **Note:**

As a point of clarification, all FRR's were attended by a combination of the following:

- FRR Board Members (outside experts from within Scaled<sup>5</sup>)
- Scaled Management
- T1b Program management
- T1b principle engineers & technicians (Project leads and Project engineers, subject matter experts, crew chiefs, etc.)
- Scaled test personnel (mission control)
- Test Flight crews (whether VG/TSC or SC)
- TSC/ VG flight test participants (mission control members, other)
- TSC/VG technical representatives (for example on PF04 we'd had key representatives of the their rocket team)
- TSC/VG management

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<sup>5</sup> The outside experts were sometimes comprised of folks outside of Scaled/ VG. For example, for rocket powered flights we often had rocket motor experts who would sit in the FRR's as part of our policy for rocket testing.

## Summary

All reviews in preparation for PF04 starting after PF03 (includes other flight test related briefings/ key milestones – descriptions foot noted)

- **GF029 FRR occurred July 17<sup>th</sup>, 2014**
- **Qualification Hot Firing One (Q1) TRR Occurred September 18<sup>th</sup>, 2014**
- **Q2 TRR occurred September 30<sup>th</sup>, 2014**
- **CF02 FRR occurred August 12<sup>th</sup>, 2014**
- **PF04 FRR occurred October 3<sup>rd</sup>, 2014**
- *GF030 occurred October 7<sup>th</sup>, 2014<sup>6</sup>*
- **Q3 TRR occurred October 8<sup>th</sup>, 2014**
- **T1b Town Hall Meeting occurred October 22<sup>nd</sup>**
- *PF04 Data systems preflight occurred October 23<sup>rd</sup>, 2014<sup>7</sup>*
- **PF04 Delta FRR occurred October 27<sup>th</sup>, 2014**
- *PF04 Card Review occurred October 28<sup>th</sup>, 2014 (AM)<sup>8</sup>*
- *PF04 Airport/FAA/First Responders Operations Briefing occurred October 28<sup>th</sup>, 2014 (PM)<sup>9</sup>*
- *PF04 Ground Operations Brief occurred on October 28<sup>th</sup>, 2014 (PM)<sup>10</sup>*
- **PF04 Executive FRR occurred October 29<sup>th</sup>, 2014**
- *PF04 Card Brief, Maintenance and ER Brief occurred October 30<sup>th</sup>, 2014 (AM)<sup>11</sup>*
- *PF04 Comm Checks occurred on October 30<sup>th</sup>, 2014 (PM)<sup>12</sup>*
- *PF04 Mission Brief occurred October 31<sup>st</sup>, 2014 (AM)<sup>13</sup>*

<sup>6</sup> GF030 was a test team proficiency flight due to the longer than expected delay to PF04.

<sup>7</sup> Event where mission control is staffed and vehicle is operated by crew-chief/ground crews. Data is extracted from the vehicle and all parameters are health checked in preparation for upcoming flight.

<sup>8</sup> Flight test cards are scrutinized for content

<sup>9</sup> Jason DiVenere briefed out of house participants on CONOPS for PF04. This review covered the big changes from PF03 as a result of the rocket motor changes and also refreshed the other interactions between all of the participants.

<sup>10</sup> Steve Losey (Crew Chief) briefed the Scaled and supporting VG teams of all of the new process, procedures and safety considerations for working with the new rocket systems (primarily (b) (4))

<sup>11</sup> Final review to resolve any small open items in flight test cards. Check of vehicle maintenance and crew/team readiness for imminent flight.

<sup>12</sup> COMM checks are staffed by the mission control team in MC, both flight crews (WK2, SS2) and the crew chiefs for both aircrafts. The communication systems (VHF, intercoms, telemetry, etc.) is tested end to end to insure mission readiness.

<sup>13</sup> Occurs morning of, just prior to flight. This is a refresher of the brief from the day before. If any changes to vehicle, crew, other status those are discussed. Mission weather is reviewed. Any other additions or changes are raised. Step from this review to the test flight.