SM4 Servicing Mission Operations

JSC Mission Operations Directorate

Flight Director Office

DA8/A. Ceccacci

April 3, 2007

5. Mission Operations - Agenda

- 5a. - Mission Overview
- 5b. - TPS Inspection Plan
- 5c. - Timeline Threats
- 5d. - Training
  - EVA Training Plan
  - Crew Training
  - Flight Control Team Integrated Training Plan – Orbit

5a. - Mission Overview: Planning

- **Pre-Mission Timeline developed/designed/planned to protect :**
  - **Shuttle Operational Flight Rules**
    - » **FD2 Surveys – TPS Health Post Ascent**
    - » **Focused Inspection (if required) for detailed assessment on AOI to "clear" TPS for Entry (Ascent debris environment)**
    - » **Late Inspection - RCC Health**
      - **MMOD #2 concern on SSP PRA list**
      - **HST Mission "manifested" based on ability to accommodate Late Inspection**
    - » **EOM+1 and EOM+2 Extension Day Requirements (2 extension days Weather/Systems required)**
    - » **EVA length (planned 6:30 hrs)**
    - » **Optimize MMOD protect attitude**
    - » **D/O Opportunity Planning**
  - **SCSC (Shuttle Crew Scheduling Constraints)**
    - » **Example – Crew day length, Pre/Post Sleep, sleep shifting for D/O, Off Duty, etc.**
  - **Nominal Shuttle house keeping**
  - **Flight Requirements/Mission Objectives/Mission Priorities (SM4)**

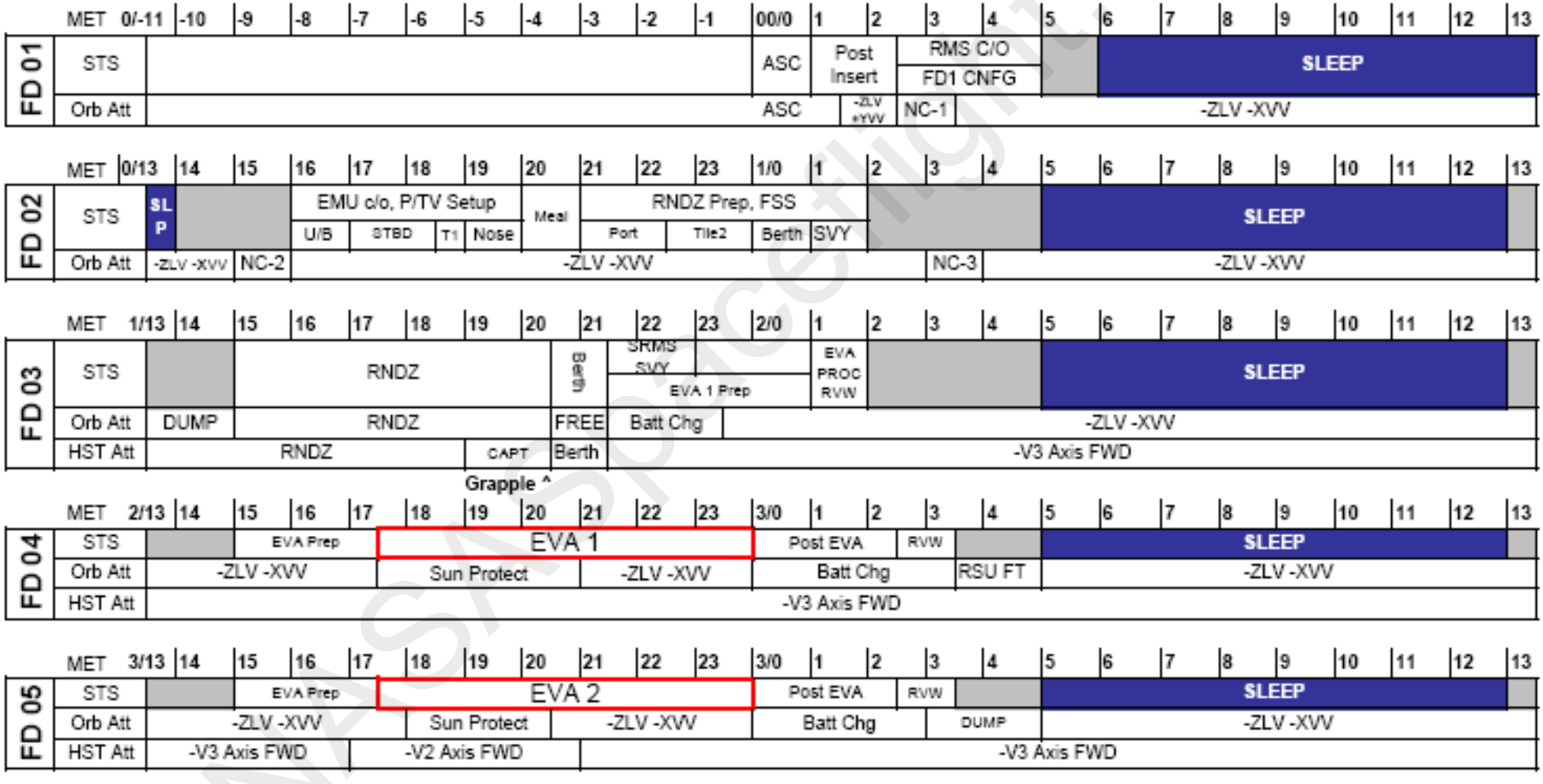
****** Underline indicates new programmatic requirements since last Servicing mission (SM3B) ******

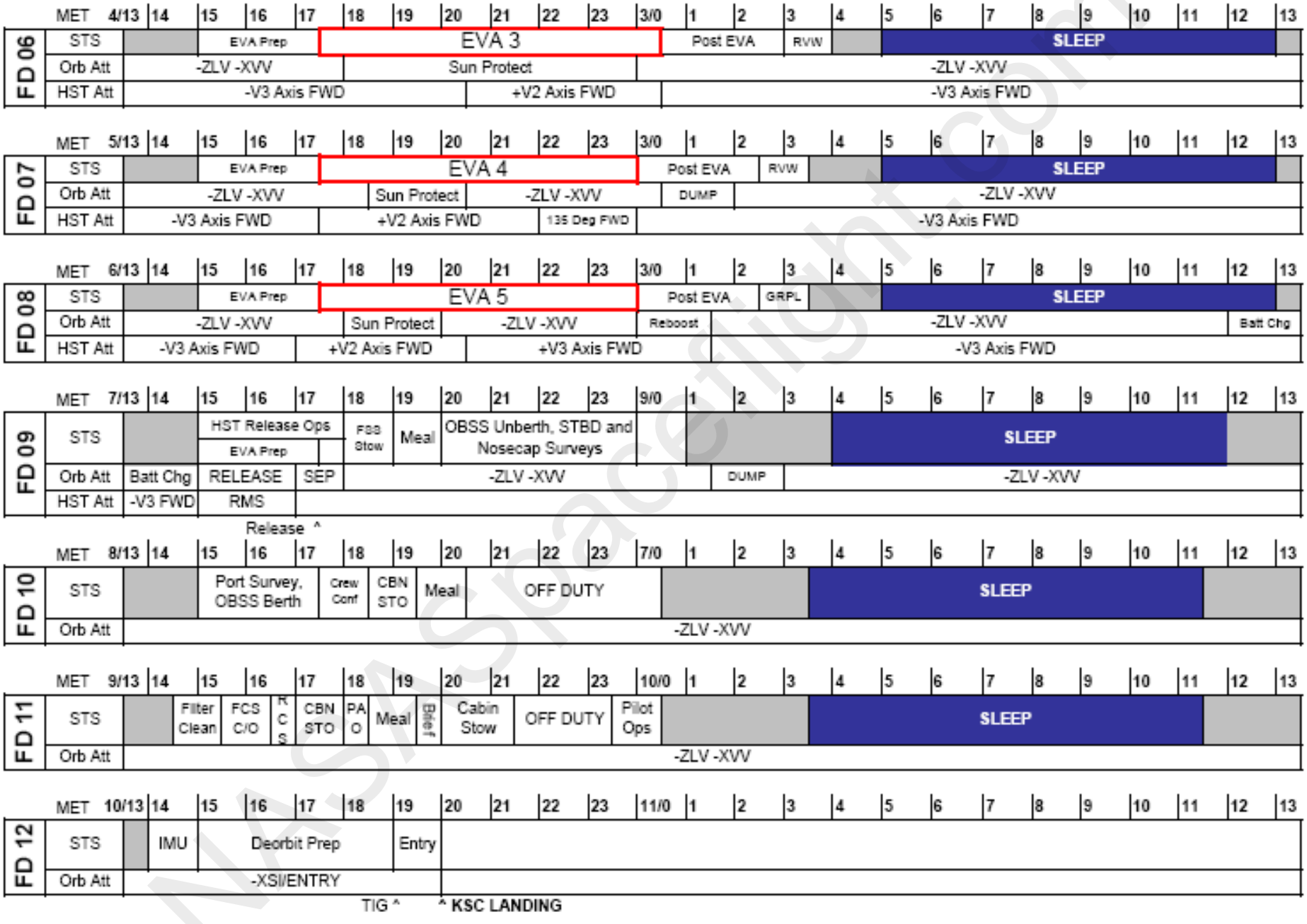
5a. - Mission Overview: Timeline Capabilities

- **Cryo limitations (5 Tanks), Programmatic requirements, and SM4 power requirements limit mission duration and content**
  - **STS-125/HST SM4 Mission is limited to a duration of 11+2 days**
  - **SM4 EVA capability is limited to 5 "scheduled" and 1 "unscheduled" EVA**
    - » **5 Scheduled EVAs (timelines as of today)**
      - **EVA 1 (RSU, Battery/Bay 3) – 6:45**
      - **EVA 2 (COS, Battery/Bay 2) – 6:50**
      - **EVA 3 (WFC III, NOBL 5, 7, and 8) – 6:10**
      - **EVA 4 (STIS, STIKER) – 6:25**
      - **EVA 5 (FGS 3, OVP, OCE-EK)- 6:30**
    - » **1 Unscheduled EVA**
      - **"Rapid response" EVA on HST Release Day**
        - **EVA Prep activities in parallel with HST Deploy activities**

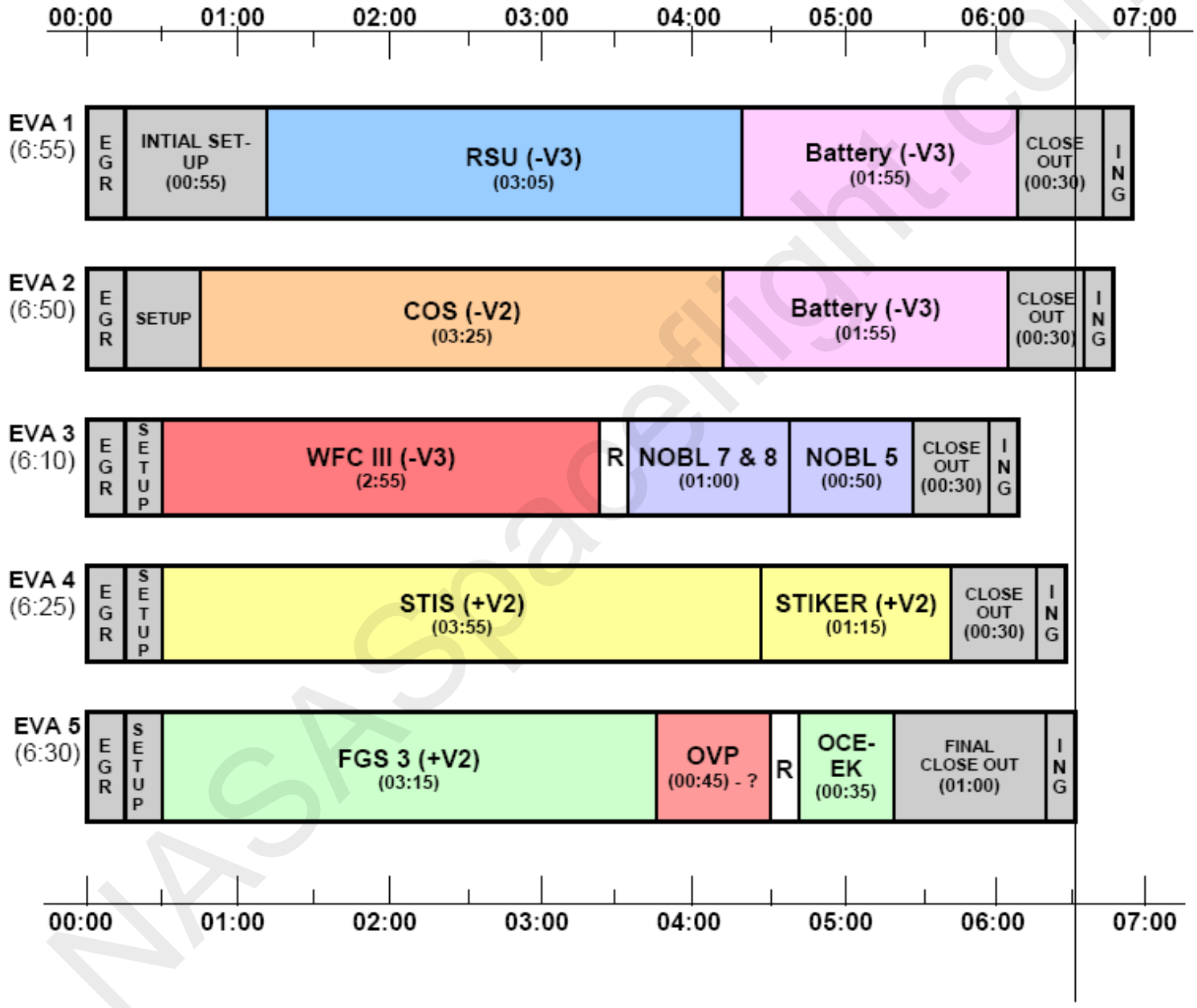
5a. - Mission Overview: SM4 Overview Timeline

HST SM4 Overview Timeline with FD09 EVA Prep (Draft Timeline)
11 Day Mission (5 EVAs)





HST SM4 EVA Timelines



5a. - Mission Overview: Unscheduled EVA Plan

- **Plan is to prepare for a "Rapid Response" EVA in parallel with HST Release activities on FD9 since limited to 1 "unscheduled" EVA**
  - **Schedule crew HST release activities/release as early as possible on FD9**
    - » **Requires HST to streamline/minimize telescope prep configuration (working with HST to define this plan)**
  - **EV crew prepped and ready to respond to "HST Deploy Day Problems" as required**
    - » **Hi Gain Ant Deploy EVA will be know the evening before**
    - » **Umb Disconnect, Unberth, APT Door Open will occur during EVA Prep, providing heads up if any of these activities cannot be successfully completed**
    - » **If the above activities go well, complete EVA prep up LVCG Donning. If EE release is unsuccessful, Complete EVA Prep and begin EMU purge and pre-breath while telescope is being re-berthed**
  - **"Rapid Response" EVA plan provides:**
    - » **Earlier planned release provides more "runway" (crew day) to support HST Deploy/Release Contingencies**
    - » **Quick response**
    - » **Maximum EVA capability/proficiency (time available ~ 6 hrs total)**
      - **To meet crew day length and Pre-sleep requirements**
    - » **Low likelihood of having to actually execute the "unscheduled" EVA due to HST and Orbiter redundancy as well as proven hardware flight history**

5b. - TPS Inspections: FD2 Surveys

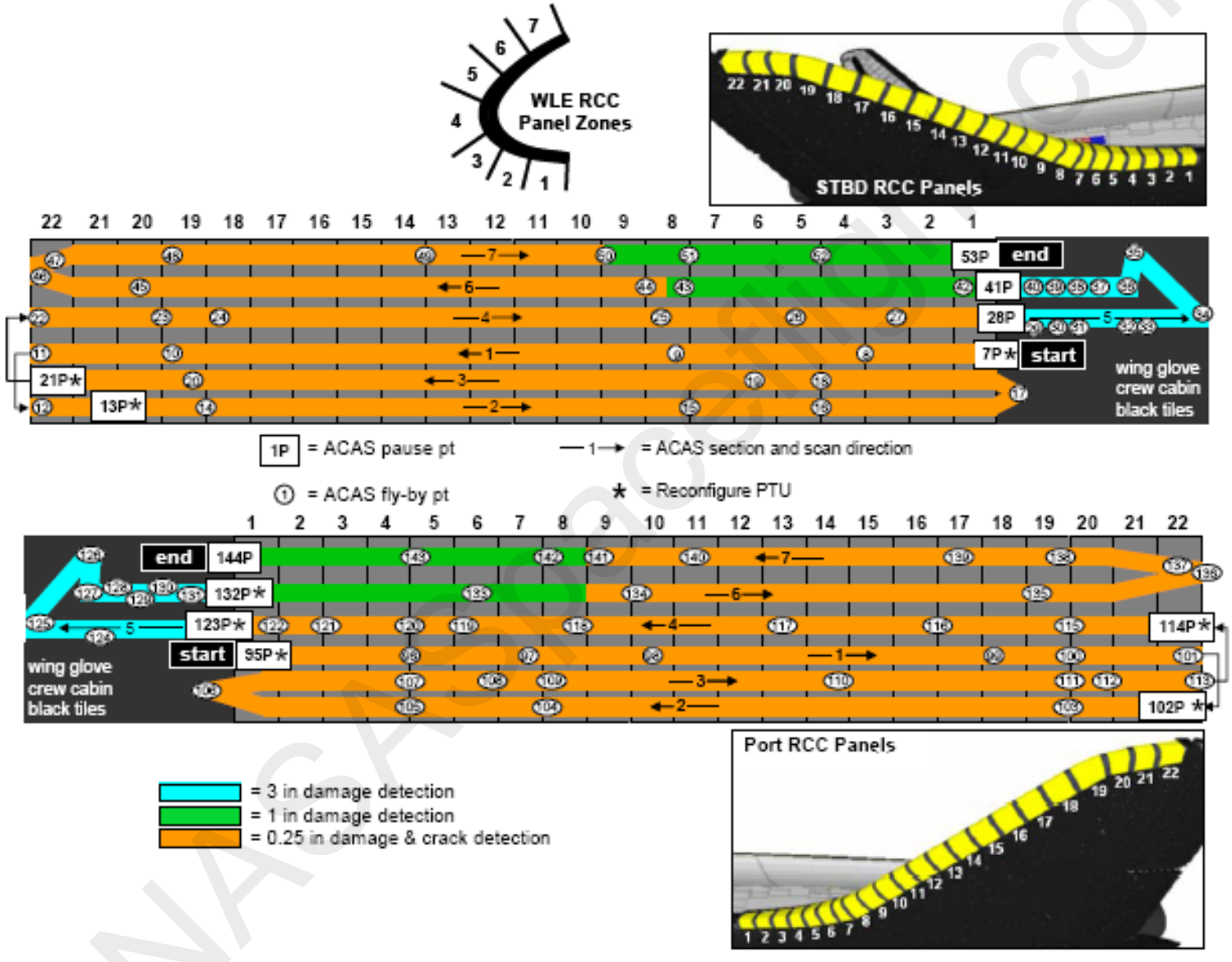
- **FD2 Surveys performed to assess health of Orbiter TPS from Ascent Debris environment**
- **Mandatory to determine health of Orbiter TPS as soon as possible so required follow on actions/activities can be initiated**
- **FD2 Surveys consist of:**
  - **LDRI/IDC WLE and Nose Cap Surveys**
  - **Crew Cabin Survey**
  - **ITVC Tile Acreage Survey**
  - **Upper Crew Cabin (TBD)**

5b. - TPS Inspections: FD2 Surveys

- **LDRI/IDC WLE and Nose Cap Surveys**
  - LDRI and IDC footprints overlap for parallel operations where possible
  - LDRI prime sensor
    - » No daylight requirements (sensor provides own illumination)
    - » Allows RCC inspection to into FD2 Timeline
  - IDC "bonus coverage/best effort imagery "
    - » IDC requires daylight to support resolution requirements
      - Major timeline hit waiting for daylight if IDC prime sensor (only 45 minutes of Orbit available)
    - » If IDC imagery resolution adequate, will be used to clear areas of interest (AOI) thus not requiring dedicated Focused Inspection
- **Crew Cabin Survey**
  - Crew Cabin survey performed in parallel with WLE survey utilizing ITVC

HOOK
VELCRO

OBSS SCAN PATTERN CUE CARD – STBD & PORT

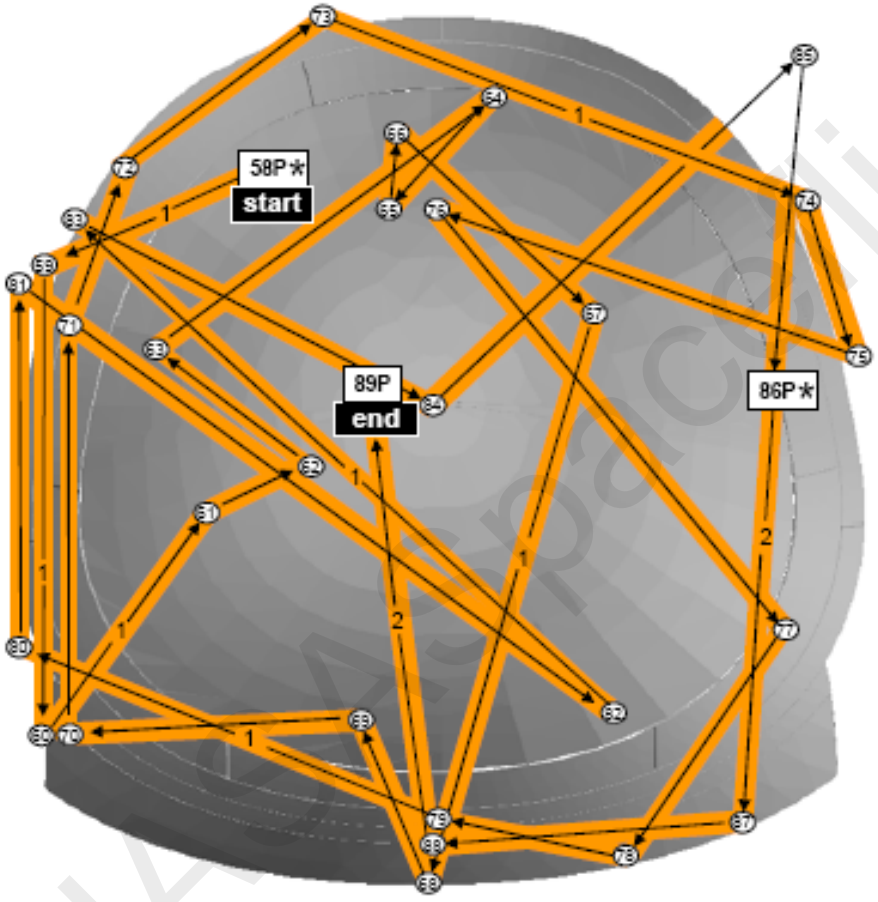


PDRS-7a/O/A

HOOK
VELCRO

OBSS SCAN PATTERN CUE CARD – NOSE CAP

= 0.25 in damage criteria
1P = ACAS pause pt
① = ACAS fly-by pt
1→ = ACAS section & scan direction
★ = Reconfigure PTU

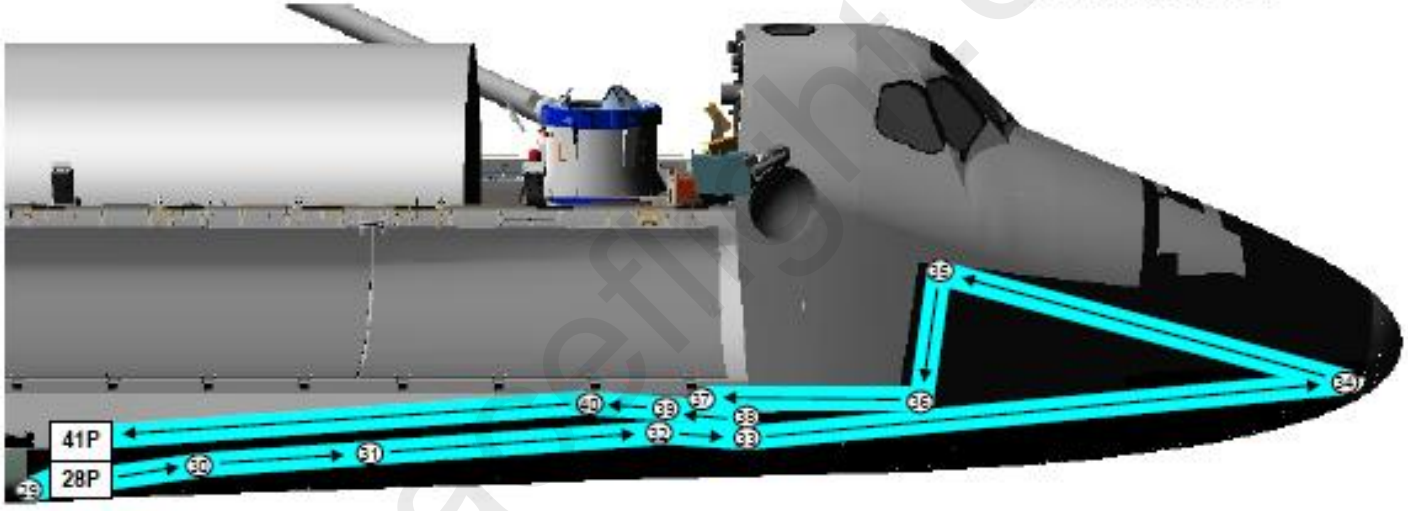


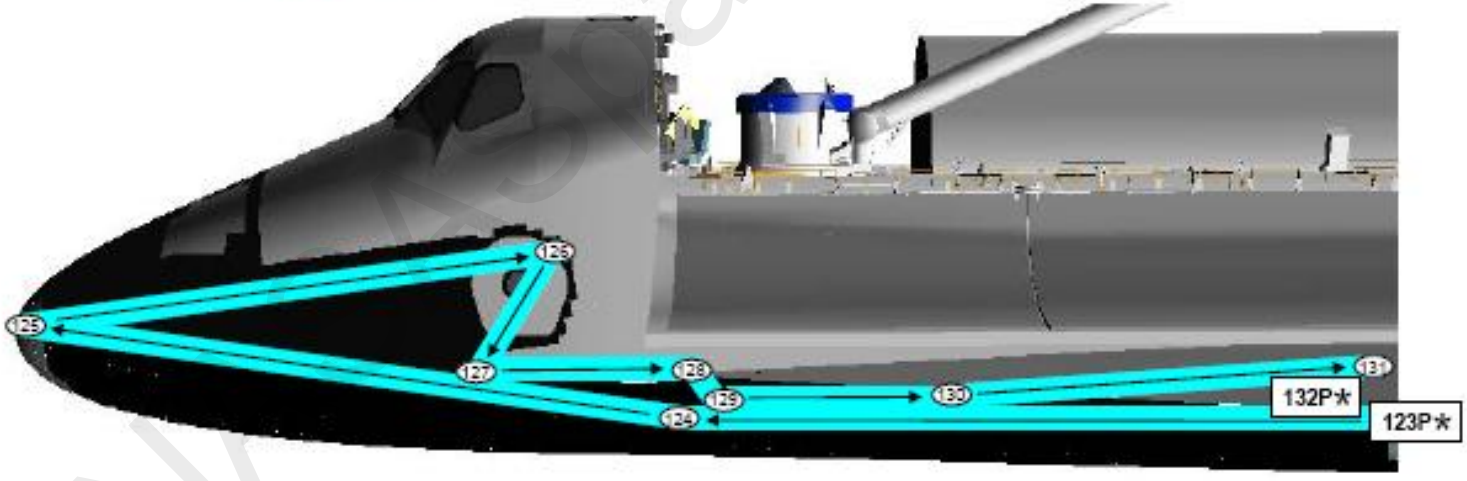
HOOK
VELCRO

OBSS SCAN PATTERN CUE CARD – WING GLOVE & CREW CABIN

= 3 in damage criteria
1P = ACAS pause pt
(1) = ACAS fly-by pt
→ = ACAS scan direction

STBD WING GLOVE & CREW CABIN





PORT WING GLOVE & CREW CABIN

PDRS-8a/O/A

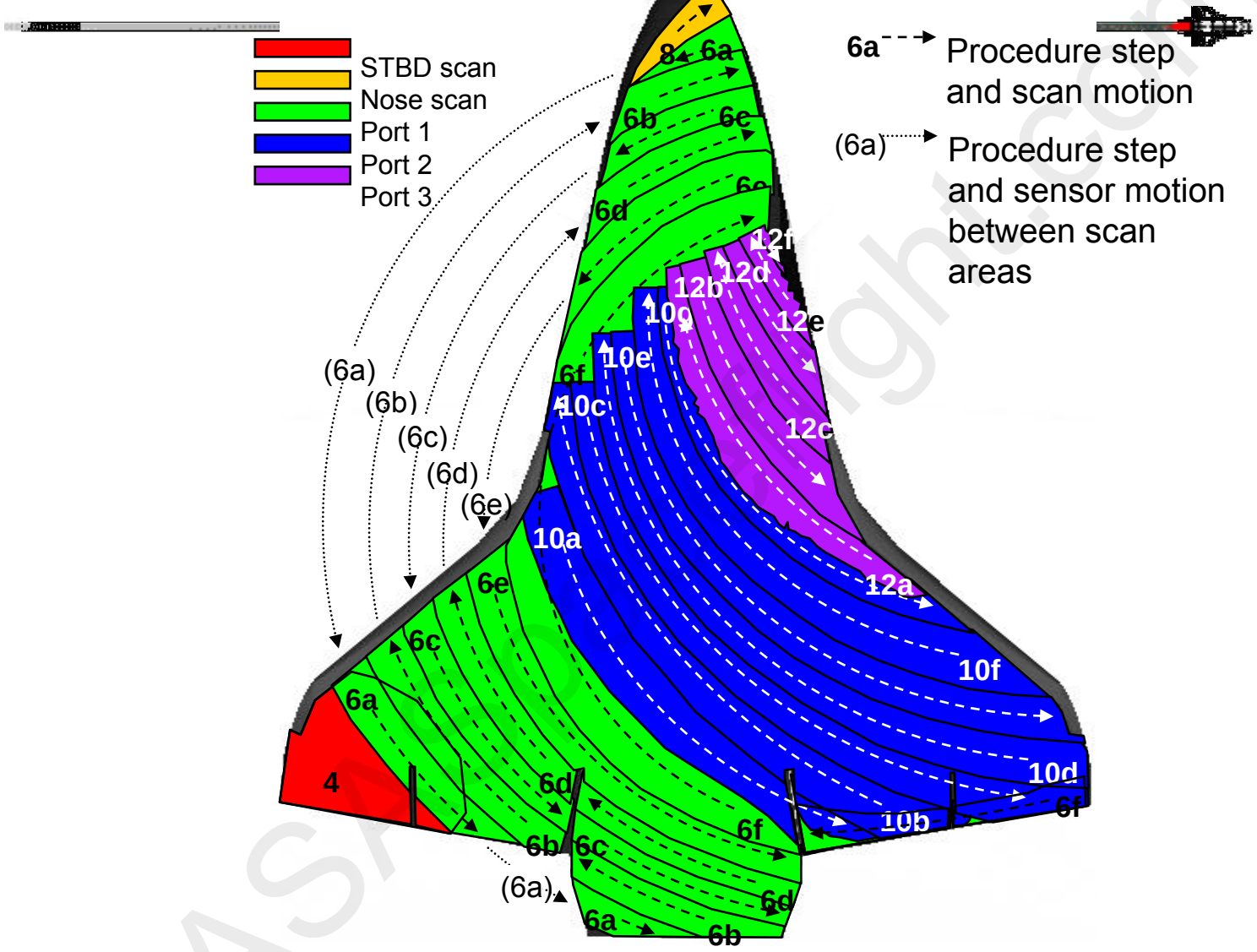
5b. - TPS Inspections: FD2 Surveys

- **ITVC Tile Acreage Survey**
  - **Replaces "RPM Photography" performed on ISS Missions**
    - » **Procedures developed in support of RTF (STS-114) in the case the RPM photos could not be accomplished**
  - **Scans "Orbiter Belly' using ITVC**
  - **Procedure update currently in progress to ensure required resolution in support of Tile Damage criteria (incidence angle/FOV).**

NOTE:

- **Actual execution time still TBD and will not be known until procedure updates complete (ECT ~ 6/07)**
- **May require time on FD3 (post HST Berth) to complete surveys**

ITVC Tile Acreage Survey Scan Pattern

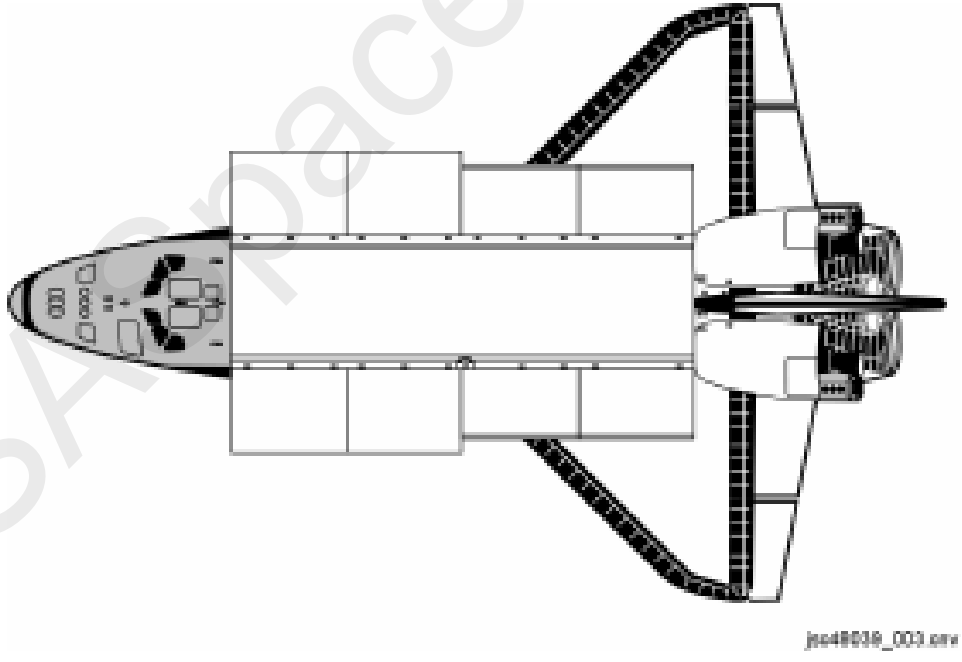


Approximately to scale. Do not use to quantify scan footprint overlap
Footprint estimates based on DOUG analysis using 45 deg surface incidence angle and ITVC HFOV = 20.0 deg RCC Excluded

5b. - TPS Inspections: Upper Crew Cabin

- **Upper Crew Cabin**
  - **Requirement "TBD"**
  - **Photo's previously obtained during RPM**
  - **RMS Exterior Survey "H" available**
  - **Options to add to RMS C/O Payload Bay Survey or SRMS Survey Post HST Berth**

EXTERIOR SURVEY H – TOP SIDE, NOSE AND OVHD WINDOWS (12 min reqd)



5b. - TPS Inspections: Late Inspection

- **Utilizes LDRI/IDC WLE and Nose Cap Surveys**
  - **Same procedure as performed on FD2**
- **Executed Post Orbit Adjust Burn (post HST Deploy)**
  - **Lower perigee (~ 330 x ~ 120) equates to a ~ 220 NM equivalent ISS altitude MMOD environment**

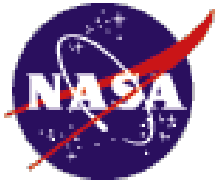
5b. - TPS Inspections: Focused Inspection

- **Focused Inspection Process**
  - **Review FD2 TPS survey data to identify AOI (area of interests) candidates to be considered for Focused Inspection**
    - » **PDRS informed of any AOI to get a head start on procedure development**
  - **Focused Inspection CHIT meeting to select mandatory AOI (if any) to be surveyed and define specific imagery requirements (sensor, views, etc.)**
  - **Procedure development, validation and crew review**

5b. - TPS Inspections: Focused Inspection

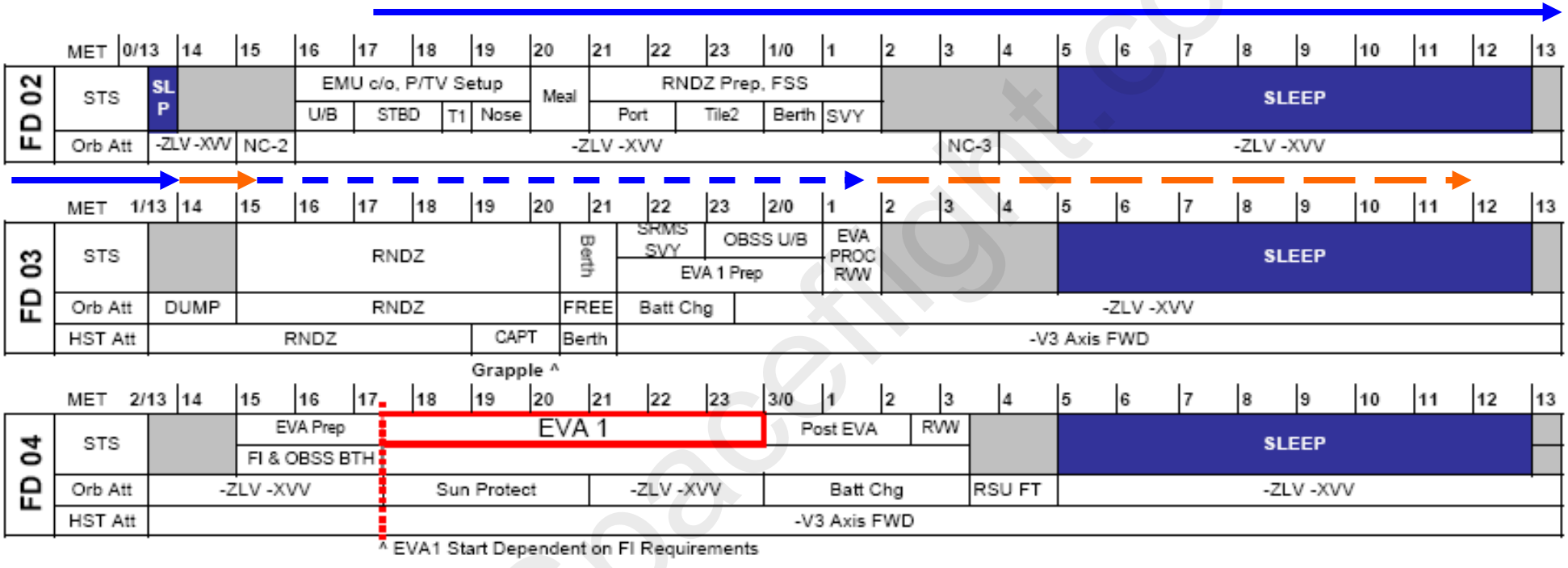
- **Focused Inspection Planning**
  - **Goal is to complete RCC and Tile Belly Acreage TPS Surveys on FD2 (~ MET 1/01:00)**
    - » **Includes completing any required "survey playbacks" prior to crew sleep**
  - **Imagery review begins as soon as first piece of survey data reaches the MCC**
  - **Goal is to complete imagery review and schedule Focused Inspection CHIT meeting by NLT FD3 rendezvous timeline start (~ MET 1/15:00)**
    - » **Have initiated discussions with TPS Imagery Inspection Group on this accelerated review**
      - **High confidence this can be completed with the additional flight experience we will gain prior to STS-125 (Detailed assessment still required)**
    - » **Streamline of Focused Inspection procedure development required (Team 4 PDRS will be utilized)**
      - **High confidence this can be completed with the additional flight experience we will gain prior to STS-125 (if not there already)**
  - **Mandatory to determine health of Orbiter TPS as soon as possible so required follow on actions can be initiated**
    - » **EVA repair, Rescue mission, etc.**

5b. - TPS Inspections: Focused Inspection



- **Timeline overview if Focused Inspection required (to minimize impact to SM4 EVAs)**
  - **FD2:**
    - » **Surveys Complete (imagery processing begins as soon as data becomes available)**
  - **FD3:**
    - » **Focused Inspection CHIT meeting complete by Rendezvous timeline start**
    - » **HST RNDZ Day**
    - » **HST Berth**
    - » **RMS Survey**
    - » **If Focused Inspection required:**
      - **OBSS Unberth**
      - **At Sleep –3 hrs (if not sooner) give crew pre-lim procedure and locations for review and comments prior to sleep**
  - **FD4:**
    - » **Focused Inspection prior to EVA 1**
    - » **OBSS Berth**
    - » **EVA 1 (task execution TBD)**

5b. - TPS Inspections: Focused Inspection



Imagery Review

Focused Inspection CHIT Meeting

Draft procedure development/verification for crew review/comments

Final procedure development/verification for uplink to crew

in “Execute Package”

5c. - Timeline Threats: FD2 Surveys

- **Goal is to complete required TPS Surveys (RCC & Tile) on FD2**
  - **High confidence this can be completed (assuming no failures) but awaiting final Tile Acreage Survey updates**
- **If unable to complete on FD2, remaining surveys will be completed post HST berth on FD3**
  - **Delay required to deconflict with Rendezvous timeline**
  - **Based on FD2 Survey order (STBD WLE, STBD Belly, Nose Cap, Port WLE, Port Belly) it is most likely that Port survey(s) would need to be scheduled on FD3 if full survey cannot be completed as planned**
    - » **Generic OBSS Unberth/Berth procedures can be used with HST berthed**
    - » **Anticipate no clearance concerns with HST with FD2 Port Survey procedures (Port arm positions clear of HST/but will need to verify)**

5c. - Timeline Threats: FD2 Surveys

- **Delay in collecting FD2 survey imagery has potential impact to Focused Inspection planning/execution**
  - **Delay in data review results in delay of Focused Inspection Process**
  - **Focused Inspection execution, if required, would be NET FD5**
    - » **Data review would not be completed until some time during crew sleep FD3 (if not later)/current plan is to have completed morning of FD3**
      - **Time not adequate/sufficient to define Focused Inspection specifics and procedure development/verification/crew review for execution on FD4**
        - **For STS-114, 121 "milestone" to support FD4 Focused Inspection was pre-sleep FD3.**
        - **Accelerated/rush of procedure development/verification**
        - **Final procedure uplinked to crew < 2 hours prior to execution (no time to fully review)**

5c. - Timeline Threats: FD2 Surveys

Focused Inspection FD5 (FD2 survey delayed)

FD1	FD2	FD3	FD4	FD5	FD6	FD7
•Ascent •PI •RMS C/O	•TPS Surveys (RCC & Tile Acreage) •EMU C/O •RNDZ Prep	•RNDZ •HST Grapple •HST Berth •Battery Charge •RMS Survey •EVA #1 RVW	•HST EVA #1 •MFR removal •Battery Charge •OBSS Unberth •EVA #2 RVW	•Focused Insp •OBSS Berth •HST EVA #2 •MFR Install •Battery Charge •EVA #3 RVW	•HST EVA #3 •EVA #4 RVW	•HST EVA #4 •EVA #5 RVW

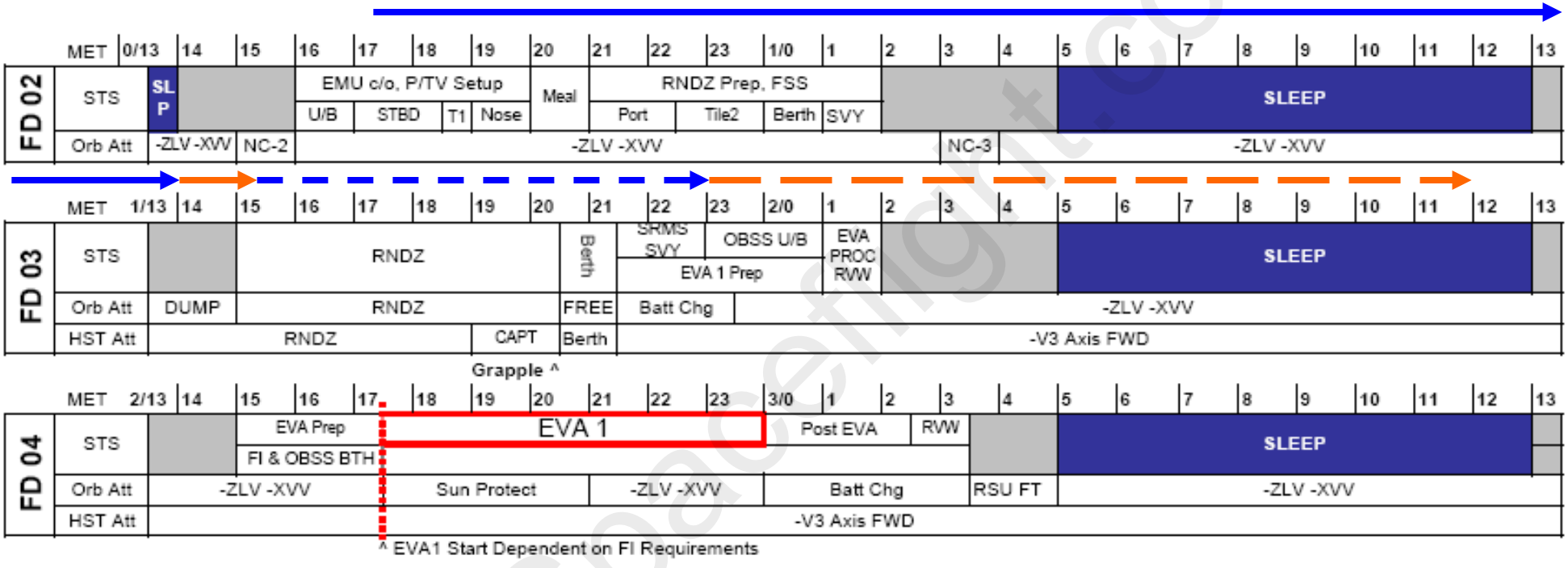
FD8	FD9	FD10	FD11	FD12	FD13	FD14
•HST EVA #5	•HST Release •OBSS Unberth •Late Inspection Part I (STBD WLE & Nose Cap)	•Late Inspection Part II (Port WLE) •OBSS Berth •Crew Off Duty	•EOM-1 •(Cabin Stow, FCS C/O, RCS Hot Fire, etc.) •Crew Off Duty	•Entry	•EOM +1	•EOM +2

- **EVA #2 execution and/or content "TBD" and is based on the time required to complete Focused Inspection which is dependent on the number of AOIs that require inspection, their location, and # of views (114 -10, 121- 6, 115 -0, 116 -0)**
- **Possibility that downstream EVA's and planning will be affected**

5c. - Timeline Threats: Focused Inspection

- **Focused Inspection and EVAs**
  - **Goal is to minimize EVA impacts and perform Focused Inspection in parallel with EVA prep activities**
  - **Possible that Focused Inspection survey time requirements may not provide sufficient time to execute all/any of scheduled EVA 1 tasks (if FI on FD4) or scheduled EVA 2 tasks (if FI delayed to FD5)**
    - » **Duration of Focused Inspection dependent on number, location, and views required of AOI**

5c. - Timeline Threats: Focused Inspection



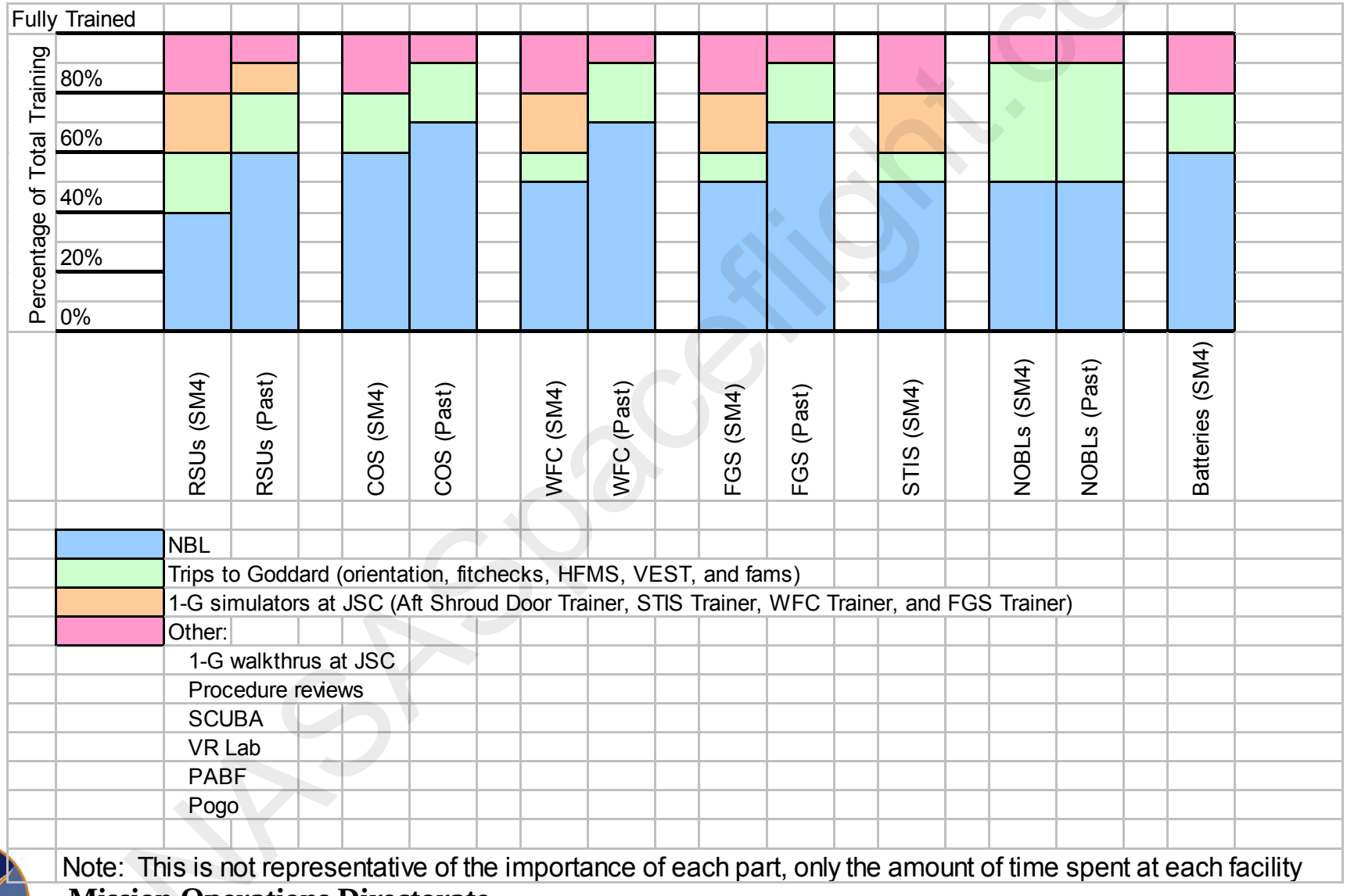
- **EVA execution (EVA 1 shown) and/or content "TBD" and is based on the time required to complete Focused Inspection which is dependent on the number of AOIs that require inspection, their location, and # of views (114 -10, 121- 6, 115 -0, 116 -0)**
- **Possibility that downstream EVA's and planning will be affected**

5d. - Training: EVA Training

- **The following chart presents the makeup of the planned EVA training for the currently defined SM4 tasks**
- **Addition of higher fidelity 1G simulators/trainers and facilities upgrades has allowed off loading of NBL tasks where appropriate**
  - **Results in more efficient training**

5d. - Training: EVA Training

HST SM4 EVA Training Makeup



Note: This is not representative of the importance of each part, only the amount of time spent at each facility

5d. - Training: EVA Training/NBL

Average Training Ratio = 12:1

NBL Training Makeup:

- **Nominal timelines:**
  - EVA 1 (RSU & Battery) = 7:1
  - EVA 2 (COS & Battery) = 9:1
  - EVA 3 (WFC & NOBLs) = 8:1
  - EVA 4 (STIS & STIK/STIKER) = 8:1
  - EVA 5 (FGS, OCE-EK, OVP) = 8.1
- **No RMS:**
  - EVA 1 (RSU) = 1 run
  - EVA 2 (COS) = 2 runs
  - EVA 3 (WFC) = 2 runs
  - EVA 4 (STIS) = 2 runs
  - EVA 5 (FGS) = 2 runs
- **Contingencies:**
  - HST Contingencies = 1 run
  - Orbiter Contingencies = 1 run
  - TPS Repair Contingency = 1 run
- **Cross Training:**
  - EVA 1 = 2 runs
  - EVA 2 = 1 run
  - EVA 3 = 1 run
  - EVA 4 = 1 run
  - EVA 5 = 1 run

Total Number of NBL Runs = 58

5d. - Training: Crew Training

- 10/31/06 – STS-125/SM4 Crew Assigned
- "Informal" Training currently in progress
- Formal Training Start Date – 8/07
- Ready Start Training (RST)/Crew SMS Training
  - L -21 Weeks
    - » Maintains average crew workload of 46 hrs/week (40 hrs/week L-4 to Launch)

5d. - Training: Flight Control Team Training

STS-125 HST SM-04 ORBIT

INTEGRATED SIMULATION REQUIREMENTS

Revision: Preliminary 3/1/07	Current Launch Date: 9/2008						
		NUMBER		HOURS			
SIMULATION	TIMELINE (MET)	JIS	WEEK-DATE	HR/SIM	SMS	MCC	NBL
FD 2 TPS Insp./FD 3 Rndz/ FD 4 EVA 1	TBD	2	L –20	57	57	57	
EVA3	TBD	3	L - 18	9	9	9	
EVA5	TBD	4	L – 16	11	11	11	
Two Short HST Deploys	TBD	5	L - 14	10	10	10	
EVA **2/Planning/EVA 3**	TBD	6	L - 12	33	33	33	
FD 2 TPS Inspection	TBD		L-10	10	10	10	
EVA4	TBD	7	L –7	9	9	9	
Rendezvous 2	TBD	8	L - 5	8	8	8	
	TOTAL	8			147	147	

SMTF: Shuttle Mission Training Facility

NBL: Neutral Buoyancy Laboratory

Simulation Supervisor: Darrel McGregor

Lead Shuttle Flight Director: Tony Ceccacci

Team Lead: ?

Mngt. Lead: ?

PTS: ? **/ FAO: Doug Bristol**

Hubble Sim Director: Debi Knapp

Back Up Charts

Summary

- **STS-125/SM4 Mission is 11+2 Duration, with 5 “Scheduled” and 1 “Unscheduled” HST EVAs (5+1)**
  - **Maximum capabilities available in support of documented SSP Requirements**
  - **Optimal plan for Mission Safety and Success**
- **TPS Inspections may possibly have an impact on the number of EVAs/EVA tasks performed during the mission**
  - **Need to ensure EVA task priorities are well defined**

Summary

- **"Unscheduled" EVA will consist of a "Rapid Response" EVA on HST Deploy/Release Day (FD9)**
  - **Rapid response required due to limited EVA availability (1 "unscheduled)**
  - **EVA will not be executed unless deploy prep or deploy problems occur (Hi Gain Ant, Umbilical, Berthing Latches, Aperature Door, RMS EE)**
  - **Focus will be resolving the above "problems" that would prevent HST from continuing operations and ensure Orbiter safety is not compromised**
  - **"Rapid Response" EVA requires minimal Telescope Prep activities to be fully successful**
    - » **Telescope prep "Long Pole"**
    - » **HST currently investigating streamlining/minimizing prep activities**

Summary (cont)

- **Plan is to utilize 5 “Scheduled” EVAs to the fullest (within 6.5 hour planning guidelines) to achieve maximum Mission Success**
  - **Servicing Task priorities and specifics (ACS repair) need to be reevaluated and defined ASAP to allow a plan to be developed to provide optimal success**

SM4 Mission Draft Timeline (11+2)

FD1	FD2	FD3	FD4	FD5	FD6	FD7
•Ascent •PI •RMS C/O	•TPS Surveys (RCC & Tile Acreage) •EMU C/O •RNDZ Prep	•RNDZ •HST Grapple •HST Berth •Battery Charge •RMS Survey •EVA #1 RVW	•HST EVA #1 •Battery Charge •EVA #2 RVW	•HST EVA #2 •Battery Charge •EVA #3 RVW	•HST EVA #3 •EVA #4 RVW	•HST EVA #4 •EVA #5 RVW

FD8	FD9	FD10	FD11	FD12	FD13	FD14
•HST EVA #5	•HST Release •OBSS Unberth •Late Inspection Part I (STBD WLE & Nose Cap)	•Late Inspection Part II (Port WLE) •OBSS Berth •Crew Off Duty	•EOM-1 •(Cabin Stow, FCS C/O, RCS Hot Fire, etc.) •Crew Off Duty	•Entry	•EOM +1	•EOM +2

- **Red Font Indicates Shuttle Program Requirements/days that cannot be traded for Mission Success (EVA's)**
  - **FD1, FD2, FD3, FD9 (Late Inspection), FD10 (Late Inspection), FD11, FD12, FD13, FD14**

SM3B Mission Timeline (11+2)

- **SM3B Mission Timeline provided for comparison:**

FD1	FD2	FD3	FD4	FD5	FD6	FD7
•Ascent •PI •RMS C/O	•EMU C/O •RNDZ Prep	•RNDZ •HST Grapple •HST Berth •Battery Charge •RMS Survey •SA Retract •EVA #1 RVW	•HST EVA #1 •Battery Charge •EVA #2 RVW	•HST EVA #2 •Battery Charge •EVA #3 RVW	•HST EVA #3 •Battery Charge •EVA #4 RVW	•HST EVA #4 •EVA #5 RVW

FD8	FD9	FD10	FD11	FD12	FD13	FD14
•HST EVA #5	•HST Release	•Crew Off Duty	•EOM-1 •(Cabin Stow, FCS C/O, RCS Hot Fire, etc.)	•Entry	•EOM +1	•EOM +2

Unscheduled EVA Plan (cont)

- **Impacts:**
  - **SCSC violation on FD10 to accomplish/complete Late Inspection**
    - » **Loss of required Crew "Off Duty" time on FD10**
- **Open Work/Issues:**
  - **Ensure adequate crew resources to support parallel operations**
  - **Minimizing HST telescope deploy/release prep activities (HST Action)**
    - » **Key to making this work**

FD8	FD9	FD10	FD11	FD12	FD13	FD14
•HST EVA #5 •Rapid Response EVA #6 Review	•HST Unsch EVA •HST Release	•OBSS Unberth •Late Inspection Part I (STBD WLE & Nose Cap) •Late Inspection Part II (Port WLE) •OBSS Berth	•EOM-1 •(Cabin Stow, FCS C/O, RCS Hot Fire, etc.) •Crew Off Duty	•Entry	•EOM +1	•EOM +2

FD2 Surveys Procedure Time-to-Execute Summary

PROCEDURE	Time on STS-116 (min)	Time on STS-117 (min)	COMMENTS
OBSS UNBERTH	60	60	No change
ITVC/LDRI FLAT FIELDS	25	N/A	Integrated in to the OBSS LDRI RCC Survey - Stbd
OBSS LDRI RCC SURVEY - STBD	90	90	
OBSS LDRI RCC SURVEY - NOSE CAP	90	50	
OBSS LDRI RCC SURVEY - PORT	90	90	
SRMS EE CAM CREW CABIN	60	N/A	Integrated into the Stbd and Port RCC surveys
OBSS BERTH	35	35	No change
TOTAL TIME (hours)	7.5	5.4	

LDRI/IDC Coverage & Criteria Summary

RCC Component	Sensor	Coverage*	Resolution Criteria*
			Passes AOI and Distance
Stbd Wing RCC	LDRI: STS-116 As Designed	100%	92%
	LDRI: New Scan	100%	92%
	IDC: STS-116 As Designed**	25%	25%
	IDC: New Scan	84%	63%
Nose Cap	LDRI: STS-116 As Designed	98%	98%
	LDRI: New Scan	100%	100%
	IDC: STS-116 As Designed**	100%	100%
	IDC: New Scan	100%	93%
Port Wing RCC	LDRI: STS-116 As Designed	98%	94%
	LDRI: New Scan	99%	95%
	IDC: STS-116 As Designed**	25%	25%
	IDC: New Scan	74%	27%

* Coverage and resolution estimates are derived from software tools and comparisons between old and new scans

** Old IDC coverage only achievable running separate IDC scan, while new IDC scans indicate potential coverage during new LDRI scan

5 Scheduled + 1 Unscheduled EVA

	65% Deg Fuel Cells		**50% Deg Fuel Cells**		25% Deg Fuel Cells	
	Margin (lbm)	Padhold (hrs)	**Margin (lbm)**	**Padhold (hrs)**	Margin (lbm)	Padhold (hrs)
H2	20.2	60.6	**23.5**	**67.2**	26.7	79.1
O2	60.6	61.5	**78.8**	**79.9**	111.9	112.8

- HST berthed 148.5 hrs (6+ days)
- HST = 522 kWh
- 5 scheduled EVAs @ 10.2; 1 cabin depress/repress
- Rapid response EVA (4.5 hr), HST deploy end of FD9
- Includes FD2 & post-unberth Late Inspection day
- 2+2+2 Deorbit Opportunities
- Without ICBC-3D