HST/SM4 Mission Timeline, EVA's and CRYO Margins

JSC Mission Operations Directorate

Flight Director Office

DA8/A. Ceccacci

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Mission Timeline Overview

- **Pre-Mission Timeline developed/designed/planned to protect (in priority order):**
  - **Shuttle Operational Flight Rules**
    - » **Example – FD2 Surveys, Focused Inspection (if required), Late Inspection, Extension Day Requirements (2 extension days required), EVA length (6:30 hrs), optimize MMOD protect attitude, D/O Opportunity Planning, etc.**
  - **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 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

Based on latest EVA Timelines

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Possible Timeline Threats

- Focused Inspection requirements
- FD2 TPS Inspection Completion
- SM4 EVA Impacts Due to Inspections (Focused/Late)

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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
    - » 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.

Focused Inspection Planning (cont)

- **Focused Inspection Process:**
  - Review survey data to identify AOI (area of interests) candidates to be considered for Focused Inspection
  - Focused Inspection CHIT meeting to select mandatory AOI (if any) to be surveyed and specific imagery requirements (sensor, views, etc.)
  - Procedure development, validation and crew review

Focused Inspection Planning (cont)

- If Focused Inspection required timeline overview (based on accelerated review):
  - 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
    - » OBSS Unberth
    - » At Sleep –X hours give crew pre-lim procedure and locations for review and comments prior to sleep
  - FD4:
    - » Focused Inspection prior to EVA
      - Need to ensure no crew resource issues to support Focused Inspection and EVA prep (don't anticipate any)
    - » OBSS Berth
    - » EVA #1
      - Actual content based on duration of Focused Inspection (# of AOI's)
      - Possible that Focused Inspection survey time requirements may not provide sufficient time to execute any of EVA#1 tasks

Focused Inspection FD4 (accelerated review)

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 •OBSS Unberth •EVA #1 RVW	•Focused Insp •OBSS Berth •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

•EVA #1 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

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FD2 TPS Scheduled Surveys

- Goal is to complete RCC and Tile Belly Acreage TPS Surveys on FD2
  - Very high confidence this can be completed
  - LDRI for RCC, ITVC for Tile
- If unable to complete on FD2, remaining procedure(s) will require completion post HST berth on FD3
  - Scheduling required (and available) post HST berth to deconflict with Rendezvous timeline
  - Flows well with SRMS survey tasks
  - FD2 survey order STBD, Nose Cap, Port
    - » Most likely that Port survey would need to be scheduled on FD3 if survey cannot be completed as planned
      - Anticipate no clearance concerns with HST with FD2 procedures as written (will need to verify)
      - OBSS Unberth/Berth procedures while HST is berthed being developed

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FD2 TPS Scheduled Surveys (cont)

- **Delay in collecting survey imagery has potential impact to Focused Inspection planning/execution**
  - **Delay in data review results in delay of Focused Inspection Process**
  - **Focused Inspection execution would be NET FD5**
    - » **Data review would not be completed until some time during crew sleep FN3 (if not later)**
      - **Time not adequate/sufficient to define Focused Inspection specifics and procedure development/verification/crew review for FD4 execution**
        - **For STS-114, 121 "milestone" to support FD4 Focused Inspection was pre-sleep FD3.**
        - **Accelerated/rush of procedure development/verification**
        - **Final procedure to crew < 2 hours prior to execution**

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

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SM4 EVA Impacts Due to Inspections

- SM4 EVA's could be greatly impacted by Inspection (Focused and Late) requirements
- TPS Health determination #1 Mission priority
- Focused Inspection required for detailed assessment on AOI to "clear" TPS for Entry (Ascent debris environment)
- Late Inspection not tradable with HST Mission success
  - » MMOD #2 concern on SSP PRA list
  - » HST Mission "manifested" based on ability to accommodate Late Inspection

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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

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

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Unscheduled EVAs

- **Program requirements limit "Unscheduled EVA" opportunities**
  - **Only option available is EVA #6 on FD9 with HST Deploy post EVA**
    - » **Results in SCSC violation (Loss of crew "Off Duty" time on FD10 to accomplish/complete Late Inspection)**
    - » **Limits EVA#6 duration to protect crew day length and support HST release**
      - **Limits tasks that could be scheduled performed**
      - **Current thought is to have a rapid response EVA for PRLA, EE, or Apt Door**
        - **Will know the evening before if the HiGain antenna deploy EVA may be required**

FD8	FD9	FD10	FD11	FD12	FD13	FD14
•HST EVA #5 •Rapid Response EVA #6 Review	•HST EVA #6 •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

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SM4 EVA Opportunities

- **SM4 EVA Opportunities Operational Impacts:**
  - **Maximum SM4 EVA's that could be performed is 6 (5+1)**
    - » **FRD requirement of 7 (5+2) cannot be met due to Shuttle program requirements**
  - **SM4 Mission priorities must be well defined**
    - » **Focused Inspection requirements may result in delaying partial or all of a EVA tasks**
      - **Lowest priority EVA/task in jeopardy**
  - **EVA #6 would consist of mandatory task(s), limited by time, to ensure Final Payload Bay closeout is completed prior to HST Deploy**
    - » **EVA duration ~ 4.5 hours**
    - » **Additional risk with HST Deploy since additional "rapid response" would possibly not be available after EVA #6 tasks completed**

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STS-125/HST SM4 Cryo Margins

DF73/Steve Patlan
February 9, 2007

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Nominal Mission (5 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	22.3	66.9	**24.6**	**73.5**	28.8	85.4
O2	77.3	78.3	**95.5**	**96.6**	128.6	129.5

- 109-like profile, HST = 499 kWh
- HST berthed 140.5 hrs (6 days)
- 5 scheduled EVAs @ 10.2; 1 cabin depress/repress
- Includes FD2 & post-unberth Late Inspection day
- 2+2+2 Deorbit Opportunities

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+1 Contingency 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

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+2 Contingency EVAS

	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	11.8	35.4	**15.1**	**45.3**	18.3	54.9
O2	-11.9	0.0	**6.3**	**6.3**	39.4	39.6

- HST berthed 168 hrs (7 days)
- HST = 578 kWh
- 5 scheduled EVAs @ 10.2; 1 cabin depress/repress
- Unscheduled EVA + rapid response EVA
- Includes FD2 & post-unberth Late Inspection day
- **Extension/weather day replaced by HST EVA day**
- 0+2+2 Deorbit Opportunities

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+1 Day Ability

- **65% FCPs assumed until L-90**
  - **Current OV-104 FCPs estimated 50% degraded for SM4**
- **SM4 Additional Day Costs**
  - **15.738 KW (Average Mission Power) x 24 hours**
    - » **O2 – 274.4 lbm**
    - » **H2 – 32.8 lbm**

6 EVAs	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

  - **Even at 50% degraded capability, far short of obtaining a +1 Day**

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ICBC -3D Cost

- **ICBC Heaters:**
  - 252 htr ops hrs, Post Insertion to Deorbit Prep
  - 10% - ZLV htrs per A2P1 (ops hrs may be conservative)
  - 12.5 lbm O2

- **ICBC PGSC:**
  - 760XD w/chassis (AC), if dedicated (not shared)
  - 252 ops hrs (probably conservative T. Myers/IMAX)
  - 13.4 lbm O2

Back Up Charts

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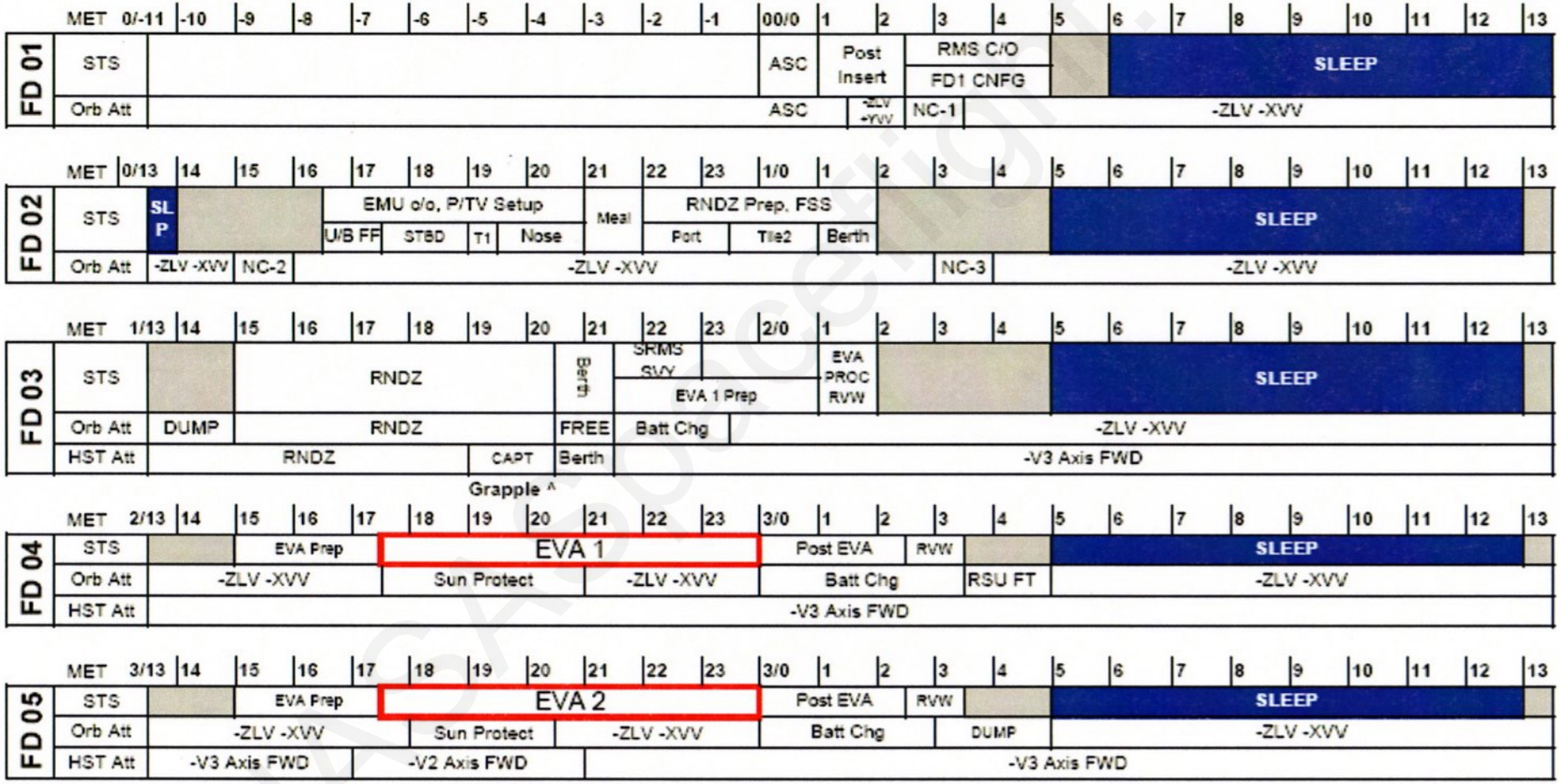
HST SM4 Overview Timeline with Late Inspection (Draft Timeline)
11 Day Mission (5 EVAs)



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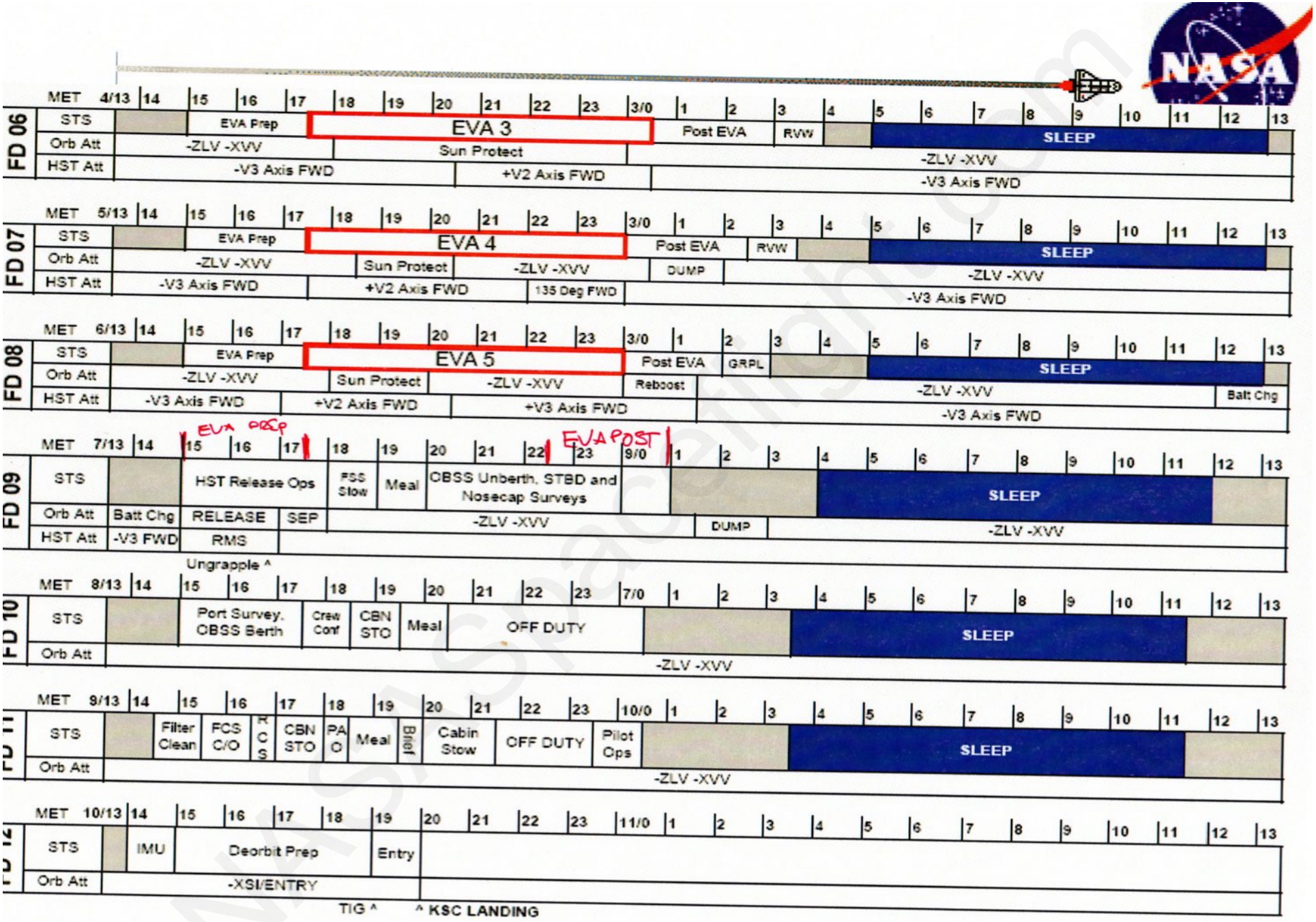

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