Sentinel-3 tandem phase

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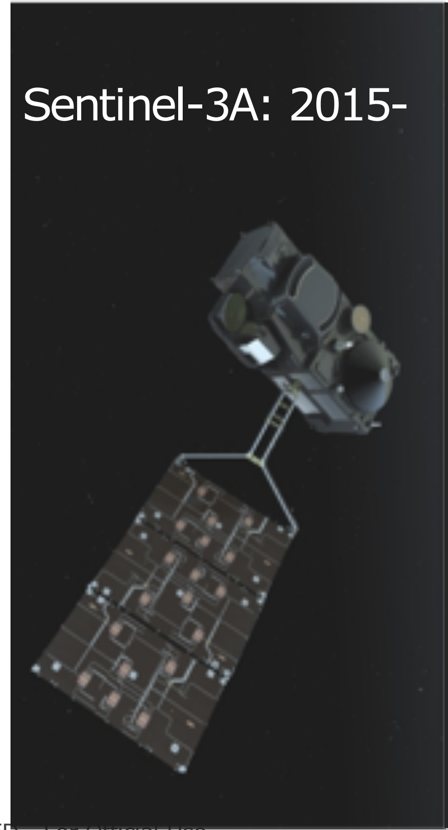
Sentinel-3 is a multi-Satellite mission



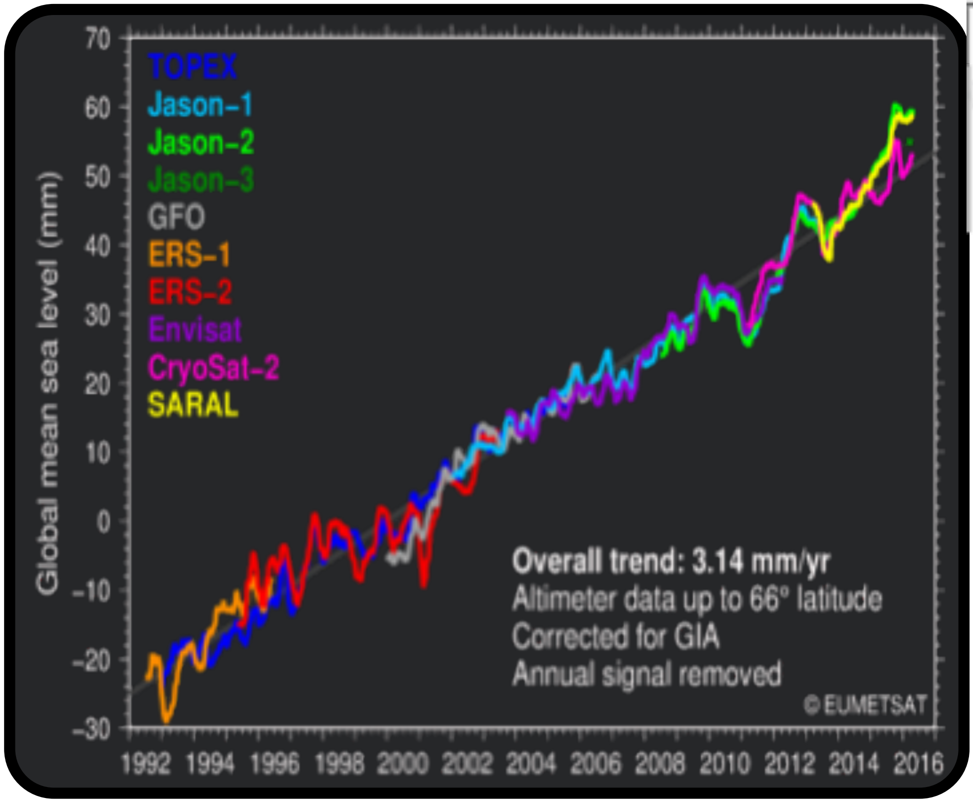
To meet Mission Requirements

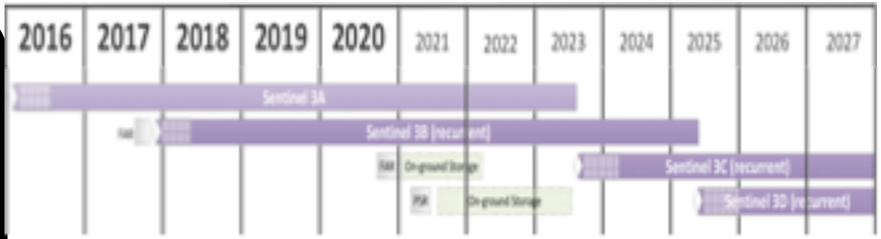
The Sentinel-3 Mission is composed of two identical satellites

Flown together in the same orbital plane separated by 140°

Follow-on Satellites (Sentinel-3C and Sentinel-3D) are now being procured.

Multi-satellite Climate data Records





- **The S3 mission includes 4 satellites**
- Even though S3A and S3B are practically identical in design, ***it is anticipated that differences in performance of payload instruments will exist***
- It is essential that **relative (absolute) bias between S3A/B/C/D instruments are known properly** for Climate Data Record construction
- GCOS Climate Monitoring principles request this approach for the climate data record.

S3 cross-satellite calibration (linking error): S3A/B Tandem flight feasibility

- A tandem phase for the S3 Mission was studied at the Sentinel-3 Preliminary Design Review (PDR)
- There is a significant correlation between end-to-end mission measurement uncertainties:
    - Uncertainty due to **geophysical ocean space and time variability** (especially in regions dominated by mesoscale structure, 1-10 days, <10-50 km)
    - Uncertainty due to **atmospheric space and time variability**
- Flying S3A and S3B close (eg. 30s) on the same ground track (+/- 1km) together **minimizes both of these aspects** and maximizes the correlation between mission measurement errors
- GCOS Satellite Climate Monitoring Principles (GCMP) requests a tandem flight for all satellite instruments
- This is exactly the approach adopted routinely by the JASON altimeter time series and stabilizes the Sea Level data set (S3 uses a transponder for range but not sigma-0)
- Exploratory studies to investigate the possibility of a limited duration (3-6 month) calibration tandem between S3A and S3B during Phase E1 verified feasibility
- **All teams working with Sentinel-3 including the European Commission fully supported the S3 Tandem phase.**

Sentinel-3 Tandem Rationale

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Sentinel-3 Tandem Implementation

Launch S3B higher than S3A. The Launch of S-3B will already initiate the drift to arrive close to S-3A.

Drift phase1: S-3B to fly ahead of S-3A: drift ~1.5 months. While still in sufficient safety distance from the S-3A position, SIOV/LEOP and commissioning of S-3B command and control can be performed. S-3B data commissioning can start.

Tandem Phase: Once S3-B command and control **commissioning is** confirmed to be OK, the approach to the actual tandem position will be initiated. A Tandem phase of maximum 5 months then follows:

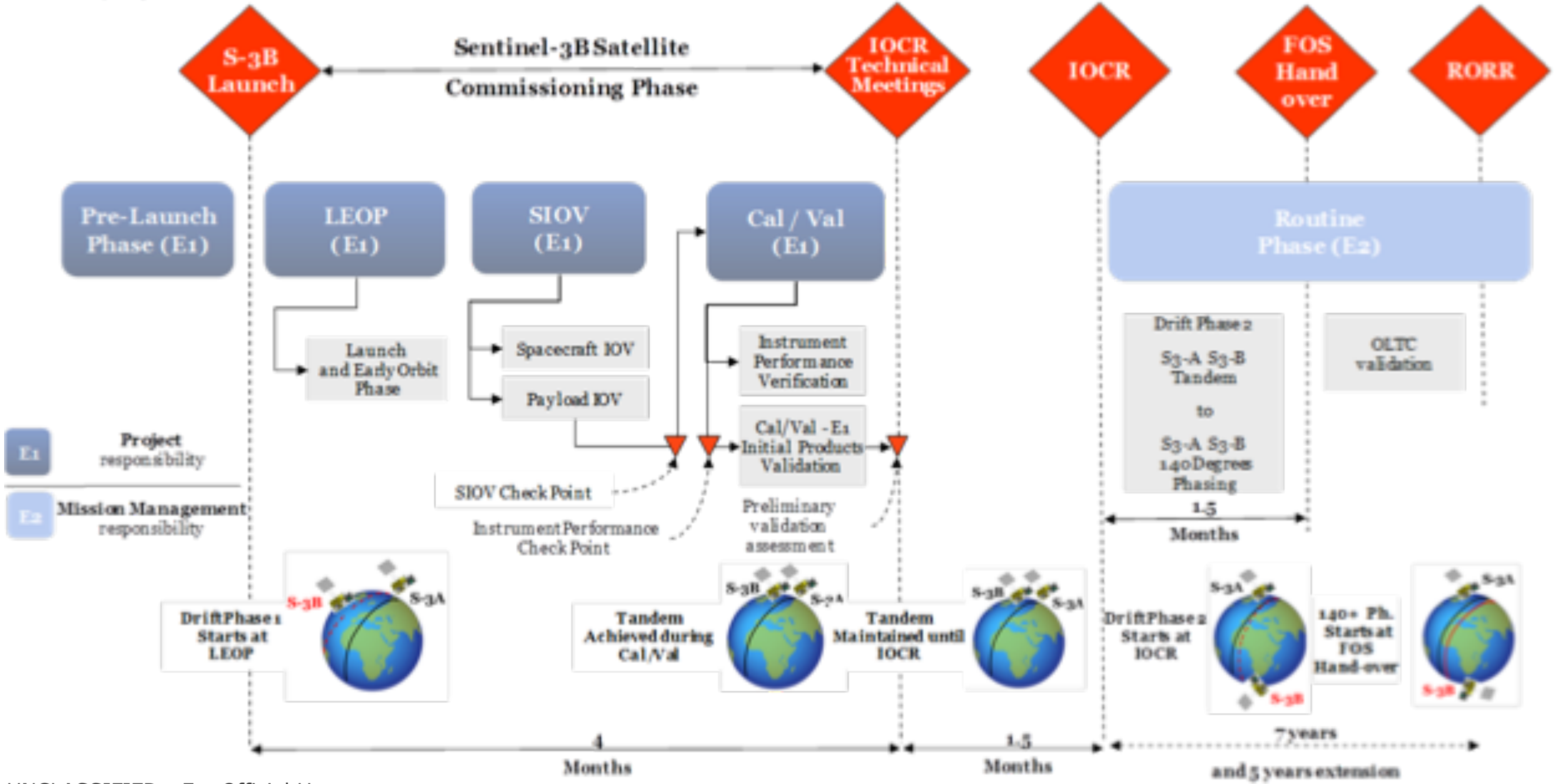
S-3A maintains normal operations.

S-3B flys ahead of S-3A with a time distance of 30 seconds (separation in position of 210 km)

S-3B continues commissioning activities

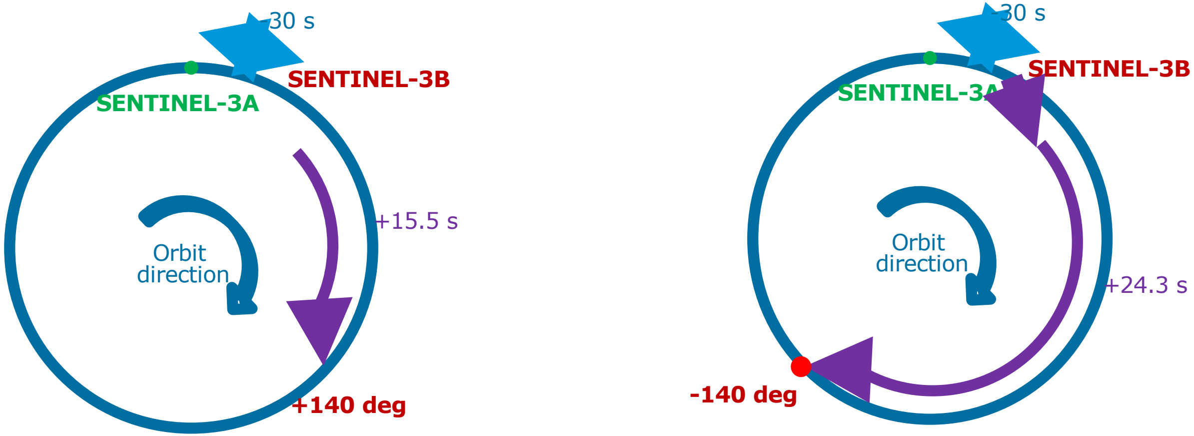
Drift phase2: S-3B to move away from S-3A and arrive at its baseline position at +/- 140 deg to S-3A. Typical duration of this phase ~1.5 months. Nominal operations start.

Sentinel 3B Commissioning: Phase Logic



Sentinel-3B: initial Tandem phase

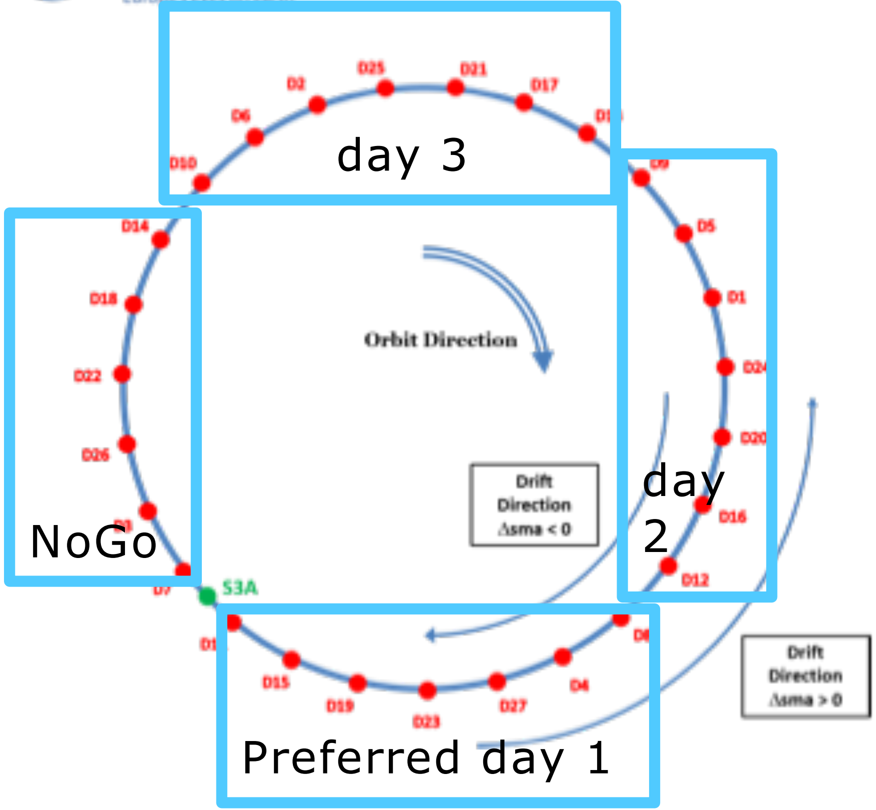
- Tandem phase keeping:
  a. In the tandem phase the orbit maintenance of S-3B shall follow the S-3A manoeuvres to keep the satellites on the +/- 1 km ground track. In this way the relative trajectory between the two satellites is maintained.
- Drift phase of S-3B
  a. Both positions at +/- 140 deg to S-3A are feasible
  b. Selection of final position can be done before end of commissioning, depending on actual situation



Sentinel-3B: initial Tandem phase

- **In conclusion the Tandem Phase has been implemented with the following effects**
  a. No impact on mission duration
  b. No impact on orbit injection strategy
  c. Small impact on fuel budget, still within allocated orbit injection budget margin
  d. The interference study confirms
     - **No S-band downlink interference for a separation distance above 8 seconds,**
     - **For interference free S-band uplink a separation of at least 20 seconds is required**
  e. Orbit control for S3-B will require
     - **To apply the EUMETSAT S-3A orbit control strategy to minimise the number of OOP manoeuvres,**
     - **To synchronise S-3B with the initial inclination and LTDN of S-3A**
     - **To synchronise the OOP manoeuvres (no more than 2d delay)**
     - **To synchronise the IP manoeuvres only on best effort basis**
  f. On FOS side stations usage analysed and demonstrated to be compatible
  g. On PDGS side
     - **Additional antenna in Svalbard implemented**
     - **Procurement, integration and testing of an additional DFEP unit**
     - **Procurement and integration of PDGS duplicated pre-processing chain in Svalbard with associated testing**
  h. On Project side
     - **Postponement of one minor Commissioning task (OLTC upload verification) after the end of the commissioning phase**

Sentinel-3B orbit acquisition



April 2018						
Mo	**Tu**	**We**	**Th**	**Fr**	**Sa**	**Su**
						1 Day 22
2 Day 23	3 Day 24	4 Day 25	5 Day 26	6 Day 27	7 Day 1	8 Day 2
9 Day 3	10 Day 4	11 Day 5	12 Day 6	13 Day 7	14 Day 8	15 Day 9
16 Day 10	17 Day 11	18 Day 12	19 Day 13	20 Day 14	21 Day 15	22 Day 16
23 Day 17	24 Day 18	25 Day 19	26 Day 20	27 Day 21	28 Day 22	29 Day 23
30 Day 24						

Table 16 : Days of the cycle in the month of April

May 2018						
Mo	**Tu**	**We**	**Th**	**Fr**	**Sa**	**Su**
	1 Day 25	2 Day 26	3 Day 27	4 Day 1	5 Day 2	6 Day 3
7 Day 4	8 Day 5	9 Day 6	10 Day 7	11 Day 8	12 Day 9	13 Day 10
14 Day 11	15 Day 12	16 Day 13	17 Day 14	18 Day 15	19 Day 16	20 Day 17
21 Day 18	22 Day 19	23 Day 20	24 Day 21	25 Day 22	26 Day 23	27 Day 24
28 Day 25	29 Day 26	30 Day 27	31 Day 1			

Table 17 : Days of the cycle for the month of May

Sentinel-3B orbit acquisition

Parameter	Injection error	Dispersion
Semi-major axis	-3.954 km	-1.0 sigma
Eccentricity	0.000963	1.2 sigma
Inclination	-0.0039 deg	-0.2 sigma
Local time	+2.2 s	+1.3 sigma

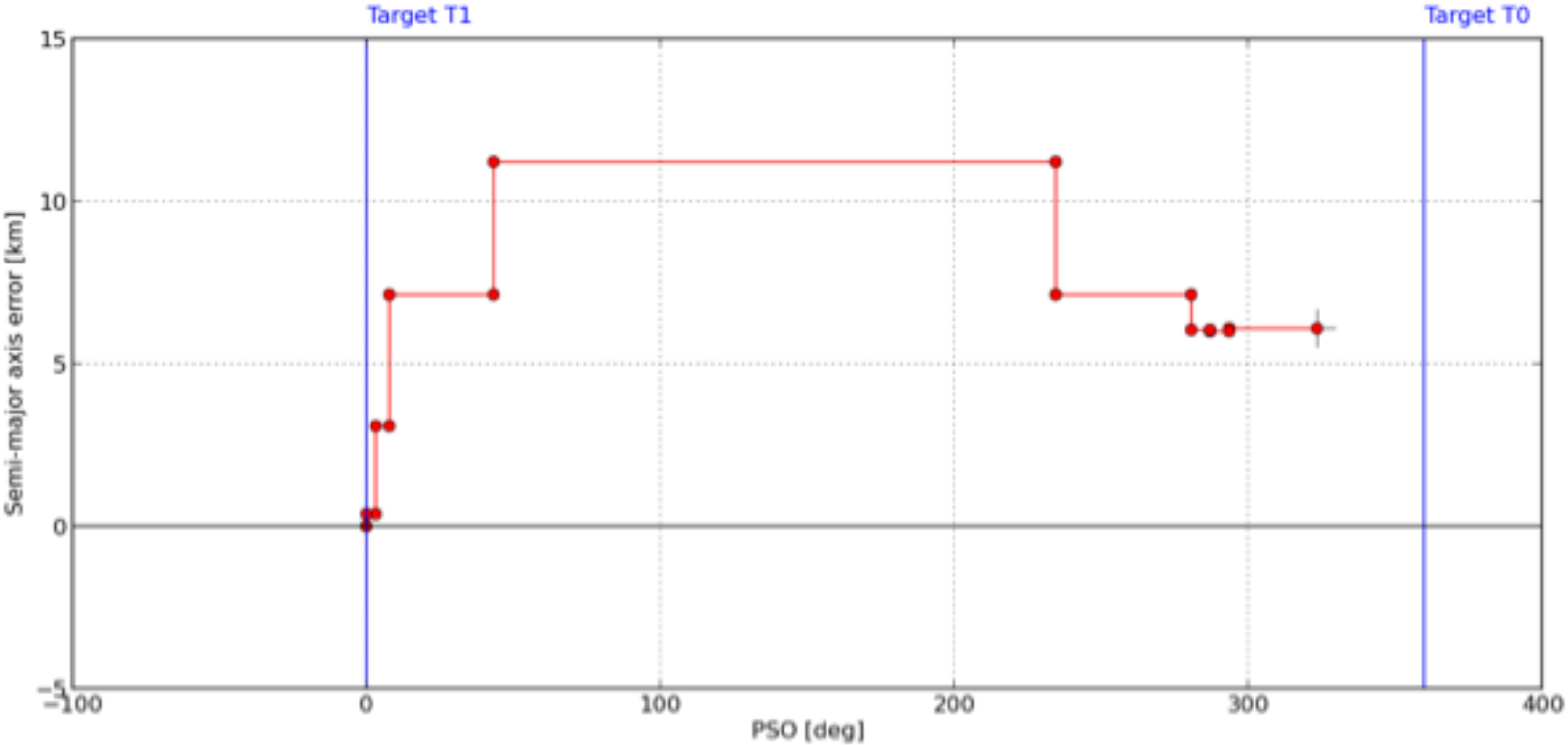
Sentinel-3B orbit acquisition

The manouvre plan

Date	Manoeuvre type	Delta-V (m/sec)
02/05/2018	Test IP (Thruster set 2)	0.655
04/05/2018	Test OOP	0.283
08/05/2018	IP (Thruster set 2)	2.020
10/05/2018	OOP	1.700
24/05/2018	IP (Thruster set 1)	-2.129
28-29/05/2018	IP (Thruster set 1)	-2.100
30/05/2018	IP (Thruster set 1)	-1.350
04-05/06/2018	OOP	-1.497
06/06/2018	IP (thruster set 1)	-0.205

Total delta-V is 11.939. This is an estimation. It is not a final value but it should be a good approximation.

Sentinel-3B orbit acquisition



Id	Title	Theme	Relevance	Feasibility	Status
0.1	Towards a metrological approach to satellite sensor comparisons	metrology	High	Good	core
0.2	Uncertainties associated with sensor comparison (generalised)	metrology	Medium	Medium	optional
1.1	SLSTR comparisons of brightness temperatures	SLSTR L1 comparison	High	Good	core
1.2	SLSTR cloud mask comparisons and geometric differences	SLSTR L1 comparison	Medium	Medium	core
1.3	OLCI-SLSTR Vis/SWIR channel comparison	SLSTR/OLCI L1 comparison	Medium	Good	core
1.4	SLSTR sub-pixel resolution for drift-phase oblique/nadir match-up	SLSTR new product	Low	Low	optional
1.5	SST comparisons from SLSTR	SLSTR L2 comparison	High	Good	core
2.1	OLCI geometric and radiometric inter-comparisons	OLCI L1 inter-comparison	High	Good	core
2.2	OLCI inter-band calibration using Deep Convective Clouds	OLCI L1	Medium	Good	optional

Summary

- A tandem phase has been implemented for the Sentinel-3A and Sentinel-3B satellites
- This provides a unique opportunity for inter-calibration and assessment of the S3A and S3B instruments
- A direct response to 3CS and Climate requirements expressed by GCOIS climate monitoring principles
- Tandem configuration will be reached by 7th June 2018
- A dedicated project called Sentinel-3 Tandem for Climate (S3TC) is in progress and will deliver all data sets for the Tandem phase pus 6 months of data in the nominal 140deg orbit configuration.
- Discussions have started as to what the approach might be for S3C and S3D tandem operations.

Thank You – any Questions

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