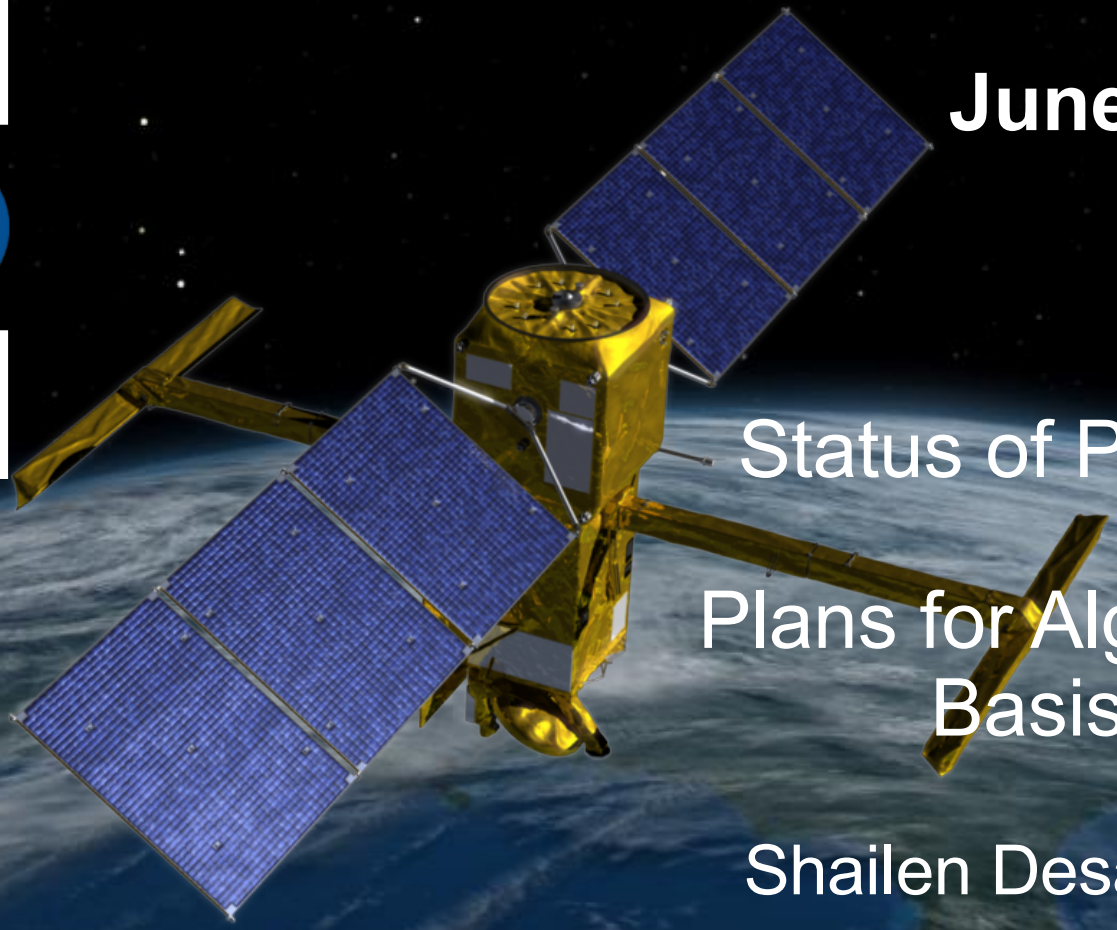
Surface Water and Ocean Topography (SWOT) Mission

June 19, 2019



Status of Product Definitions and Plans for Algorithm Theoretical Basis Documents

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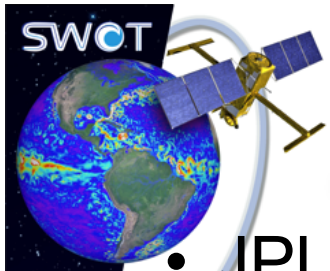
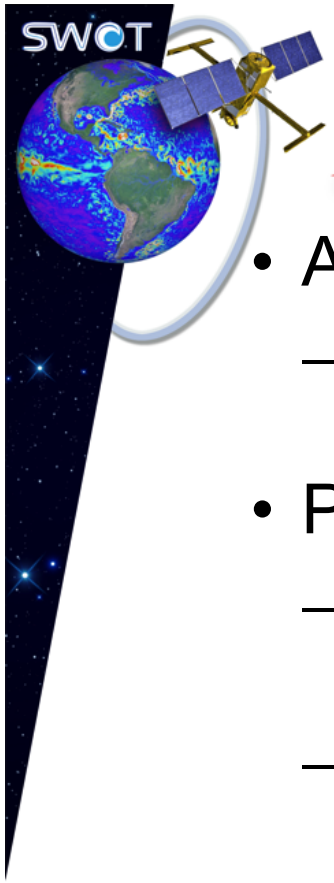


Introduction

- JPL/CNES Algorithm Development Team (ADT) generates:
  - **Product Description Document (PDD) for each data product**:
    - Qualitative description and detailed format for each science data product.
    - **Focus of ADT over last year and continuing through end of 2019.**
  - **Algorithm Theoretical Basis Document (ATBD) for each data product:**
    - Expected by early 2020.
  - **Sample data products:**
    - Generated **after** Product Descriptions reviewed by SMEs.
  - **User Handbook:**
    - Generated after baseline product descriptions available for all products.
    - Expected early 2020.
- Science Team Subject Matter Experts (SMEs) review and provide input to PDDs and ATBDs.
- Documents become publicly available after SME review inputs taken into account.



Context of ATBD, PDD, and User Handbook

- ATBD targeted to the more-expert user.
  - Users interested in the details of how reported variables are computed.
- PDD targeted to the general user.
  - Capture as wide of an audience as technically feasible.
    - High level qualitative descriptions of parameters in the product.
  - Especially, users likely to find the ATBD to be challenging.
    - Some (but only where necessary) references to ATBD primarily as recommended reference for more-expert user.
      - Where lengthy technical description would be alternative.
      - No references to specification sections or equations from the ATBD.
  - Aimed to be as self-contained as feasible.
- User Handbook targeted to ALL users.
  - Provides general context of SWOT and its measurements that apply to all of the ~10 SWOT standard data products.

User Documents

User Handbook

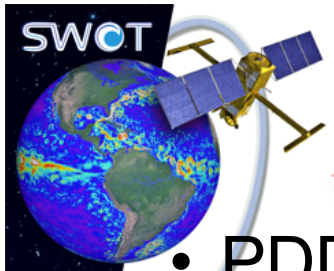
- Mission Overview, Terminology and Definitions
- Mission Design and Payload
- Basic Measurement Principles of Payload
- Radar phenomenology
- Geophysical contributors to measurements
  - E.g., media delays, MSS, tides, etc.
- Processing flow

Product Description Documents

- Separate document for each science data product
- Product-specific content
- Structure
- Qualitative description
- Detailed format and content
- Size and latency

Algorithm Theoretical Basis Documents

- Separate document for each science data product
- Physical and mathematical basis of algorithms.
- Describes how variables in products are computed.
- Qualitative description of input and output data

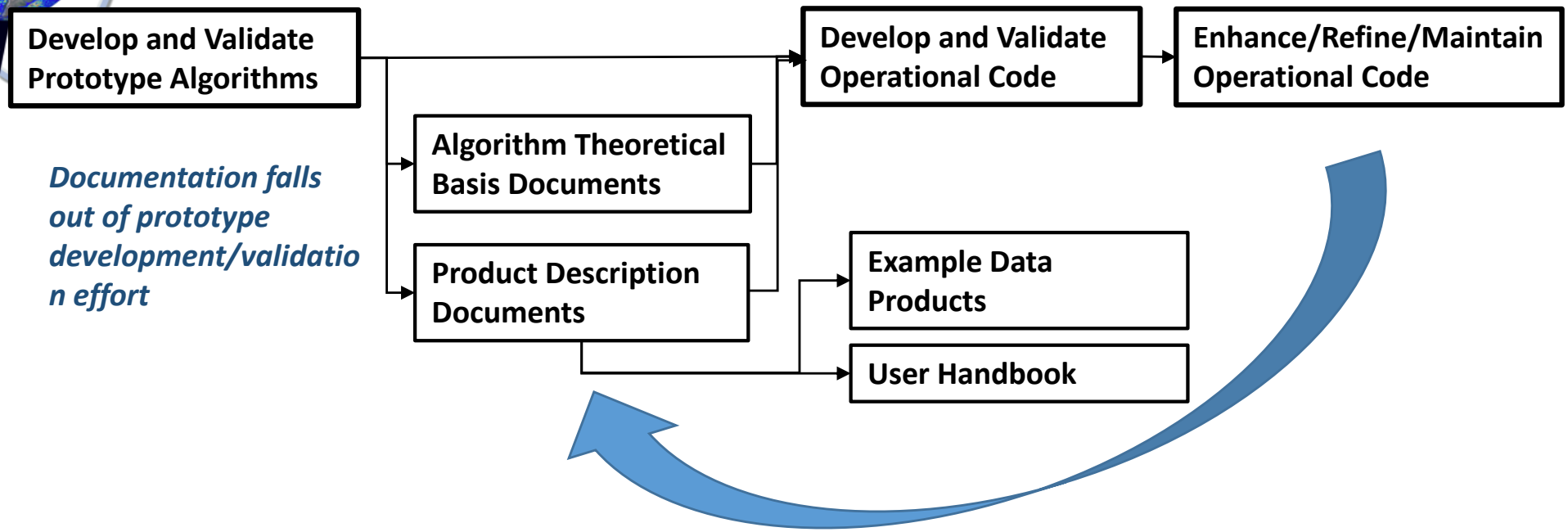


KaRIn vs. Nadir Altimeter

- PDDs and ATBDs for KaRIn science data products are the primary focus for review/input from SWOT science team.
  - These algorithms are novel for SWOT.

- PDDs and ATBDs for nadir altimeter science data products, including orbit determination(e.g., POE/MOE) have strong heritage from Jason-series (Jason-1/2/3).
  - SWOT to use best available Jason/Sentinel-6 standards.
  - ATBDs were comprehensively reviewed during Jason-1 mission development by Ocean Surface Topography Science Team.
  - Available to SWOT science team upon request to CNES project (@N. Picot).
    - Ongoing evolutions to align products and algorithms to Jason-CS standard.

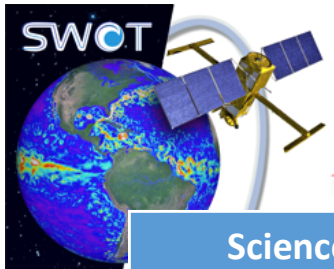
KaRIn PDD/ATBD Development Approach



- All documents expected to evolve through pre-launch.
  - Potentially during reprocessing opportunities.
- Evolution begins with mature baseline version for review by subject matter experts.
  - Prototype algorithms serve as basis of baseline documents.

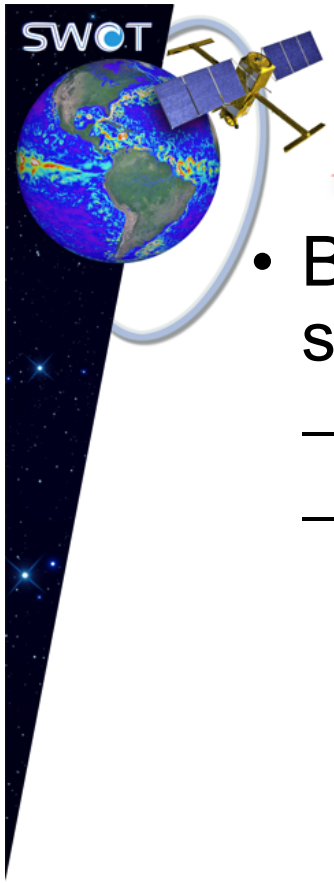
KaRIn Low Resolution (Oceans) Science Data Products

Science Algorithm	Description	Subject Matter Experts	PDD SME Review Status
L2_RAD_GDR	Level 2 radiometer product with measurements of wet troposphere delay and sigma0 atmospheric attenuation from downlinked data.	S. Brown B. Picard	Completed
L1B_LR_INTF	Level 1B product with 9-beam interferometric, correlation, and power data corrected for instrument effects from 9-beam downlinked data.	T. Farrar B. Chapron A. Mouche	Released to SMEs May 3, 2019.
L2_LR_SSH	Level 2 sea surface height data products. Consists of 4 files: 1. Basic SSH on 2x2 km geographically fixed grid 2. Wind and wave on 2x2 km geographically fixed grid 3. Expert SSH with Wind and Wave on 2x2 km geographically fixed grid 4. Unsmoothed SSH product on 250x250 meter center beam grid (500 m resolution)	G. Dibarboure S. Gille, E. Zaron E. Cosme B. Laignel N. Ayoub	Release to SMEs in July 2019.



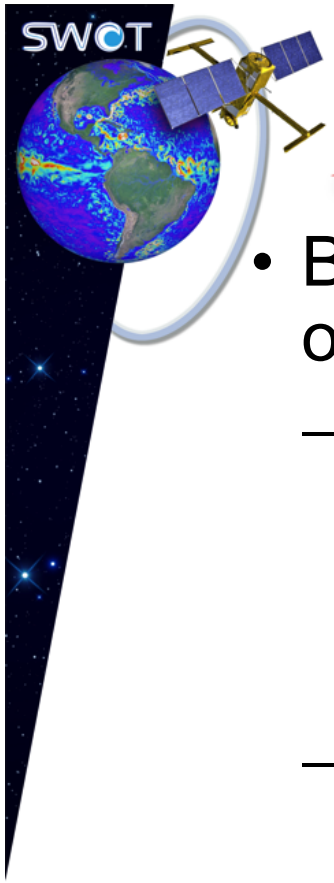
KaRIn High Resolution (Hydrology) Science Data Products

Science Algorithm	Description	Subject Matter Experts	PDD SME Review Status
L1B_HR_SLC	Level 1B single-look-complex (SLC) data product with SLC images, calibration information, time-varying platform and radar system parameters.	S. Hensley H. Yésou	Completed
L2_HR_PIXC	Level 2 pixel cloud data product with geolocated water elevations, water classification, surface areas.	M. Durand H. Yésou D. Blumstein	ADT Updating with SME Inputs
L2_HR_RiverSP L2_HR_RiverAvg	Level 2 river data products with center-line locations, widths, heights, slopes, discharge, and flags for sub-reaches and total reach. _SP product extends over single pass over continent. _AVG product aggregates over one basin (or region) within one repeat cycle.	L. Smith P.-A. Garambois S. Ricci	Release to SMEs in July(SP) and October (AVG) 2019.
L2_HR_LakeSP L2_HR_LakeAvg	Level 2 lake data products with height, geolocation, and shape. _SP product extends over single pass over continent. _AVG product aggregates over one basin (or region) within one repeat cycle.	Y. Sheng J.F. Cretaux H. Yésou	Release to SMEs in July (SP) and October (AVG) 2019.
L2_HR_Raster	Level 2 raster product with resampled single-pass heights and inundated area on a 2-D fixed UTM grid (100 m and 250 m)	M. Simard S. Biancamaria M. Grippa F. Pappa	Release to SMEs in November 2019



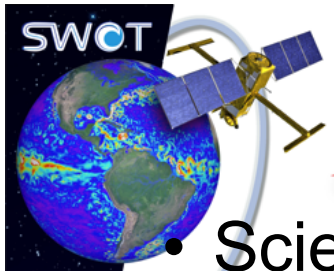
SWOT KaRIn Routine Products

- Baseline to generate routine (forward processing) science data products with latency goal of < 3 days.
  - Maintain requirement for 45-day latency.
  - Generated using preliminary inputs:
    - Preliminary orbit ephemeris, crossover calibration, radiometer calibration, model for dynamic atmosphere correction, Earth pole location, climatology (vs. optical-based) ice flag.
    - Expected to meet project requirements based upon current best estimates.
      - **Hydrology height error from 5.4 to 5.7 cm.**
      - **No change to hydrology slope error.**
      - **Negligible impact to sea surface height spectrum requirements.**



SWOT KaRIn Reprocessed Products

- Baseline includes enhanced reprocessing plan (~ once/year):
  - Achieve best accuracy that was originally intended from 45-day latency.
    - Use precise orbit determination, radiometer calibration, crossover calibration, model for dynamic atmosphere correction, Earth pole location, ice flag based upon optical imagery.
  - **Leverage expected evolution of science data algorithms when in-flight data become available, and hydrology databases.**
    - KaRIn instrument processing algorithms are certain to evolve when first-of-its-kind in-flight data become available.
  - Forward processing transitions to algorithms used in reprocessing.
    - Facilitates self-consistent time series across life of mission.



Conclusion

- Science Team SME review of Product Description Documents ongoing.
  - Expected to continue through the end of 2019.
  - General release to science team after SME review.
- Sample data products to be released when SME Review completed.
  - Joint JPL/CNES project to generate representative sample products over continent scale for Hydro and globally for Ocean
- Science Team SME review of ATBDs to begin by end of 2019.
  - Expected to continue through early 2020.
- New baseline for forward and reprocessing KaRIn products.
  - Forward processing latency goal of < 3 days and ~once/year reprocessing.

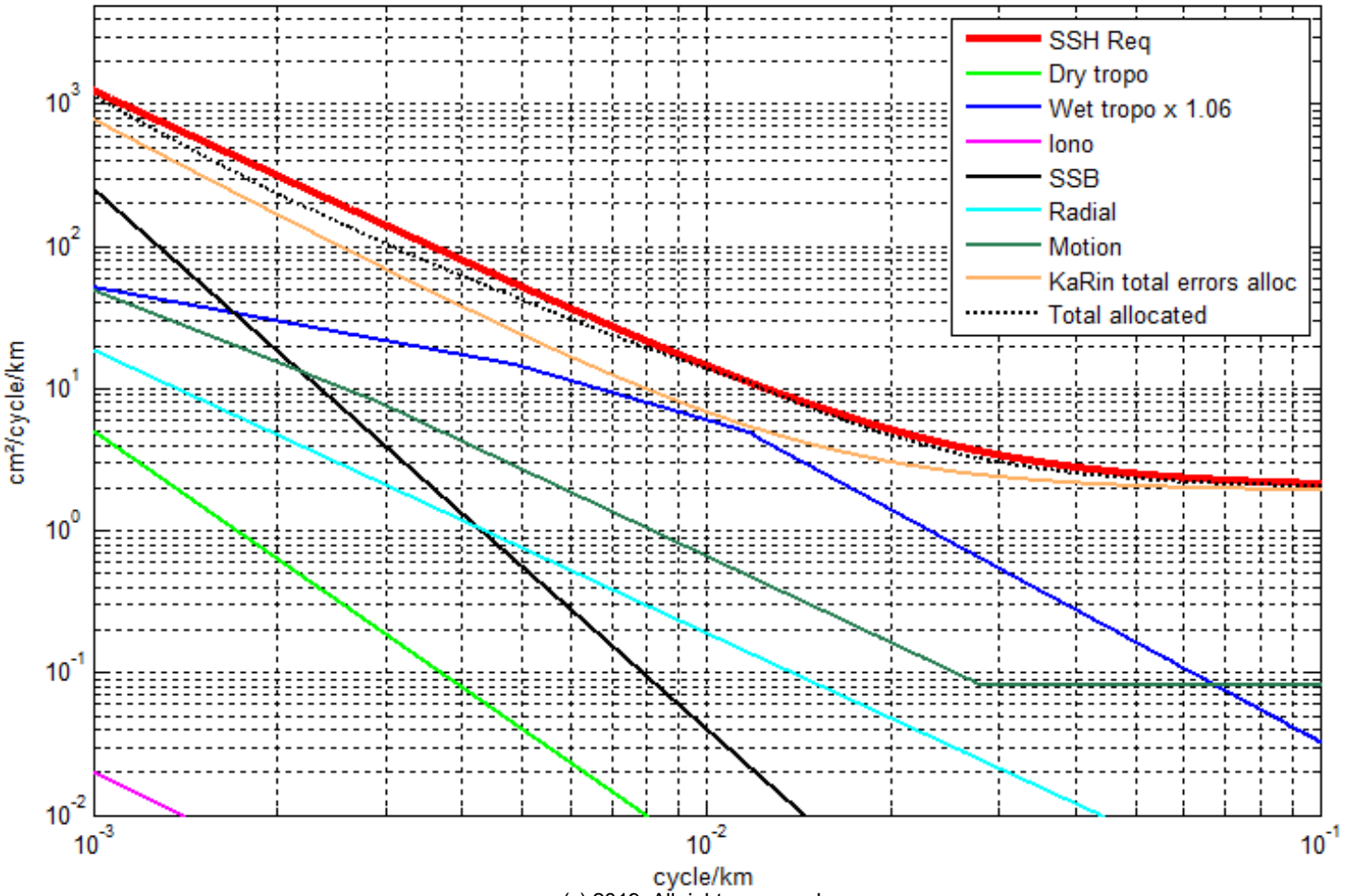
Backup

SWOT ATBD Review Approach

- Subject matter experts (SMEs) from science team have been identified by science leads.
  - Responsible for inputs and concurrence of KaRIn ATBDs and Product Descriptions on behalf of science leads.
    - Provide detailed review and input.
    - Request that SMEs be single lead point of contact with lead author of each ATBD.
      - Consolidate input from other members of science team.
      - Welcome input from all members of science team through the subject matter experts.
      - Resolve conflicts between science team requests.
  - Iterate with algorithm development team as necessary.

Summary of Performance Impact for Oceans

- **Negligible impact to ocean error spectrum** even if scaling wet troposphere error contribution by 6% to allow for calibration error at short latencies.



Summary of Performance Impact for Hydrology

- **Small increase in height error (5.4 to 5.7 cm), and no impact to slope error.**
  - **Significant remaining margin based upon current best estimates.**

	Reprocessed		3-Day Latency		
Hydrology Error Component	Height Error [cm]	Slope Error [urad]	Height Error [cm]	Slope Error [urad]	Comments
Ionosphere residual	0.8	0.1	0.8	0.1	Same GIM correction is used
Dry troposphere residual	0.7	0.1	0.7	0.1	Same ECMWF model is used
Wet Troposphere residual	1.0	1.5	1.0	1.5	Same ECMWF model is used
Radial Error	1.6	0.02	2.0	0.02	Radial Error (including POD+CoM to Phase Center radial) RMS **MOE has a slightly degraded quality**
KaRIn Random and Systematic Errors after Cross-Over Correction	4.9	10.6	5.1	10.6	KaRIn roll-up, after cross-over correction
KaRIn Random	3.0	10.5	3.0	10.5	Identical
KaRIn Systematic errors after cross-over correction	3.88	1.01	4.14	1.01	Operational Calibration analysis of residual error
High Frequency errors	0.084	<0.1	0.084	<0.1	Identical
Motion Errors	0.4	0.8	0.4	0.8	Identical
Total (RSS)	**5.4**	**10.7**	**5.7**	**10.7**	
Requirement	**10**	**17**	**10**	**17**	
Margin	**46%**	**37%**	**43%**	**37%**	