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FY2018 Integrated Strategic Transient Experiment Plan (ISTEP)

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REVISION LOG

Rev.	Date	Affected Pages	Revision Description
0	02/06/17	All	See eCR 647457. New issue.
1	02/15/17	All	See eCR 647578. Revision.
2	03/19/18	All	See eCR 654539. Revision

SUMMARY

The Integrated Strategic Transient Experiment Plan (ISTEP) purpose is to describe the FY18 Annual Test Plan, outyear projections of transient experiment program customers testing campaigns, and associated integrated schedule of preparation and post irradiation examination activities.

CONTENTS

SUMMARY 3

ACRONYMS 5

1. FY18 ANNUAL TEST PLAN 6

2. SUMMARY OF TRANSIENT EXPERIMENT PROGRAM CUSTOMERS 7

3. FUNDING ASSUMPTIONS 9

4. THE INTEGRATED STRATEGIC TRANSIENT EXPERIMENT PLAN 9

5. SCHEDULES 10

TABLES

Table 1. FY18 Transient Experiments. 6

ACRONYMS

ATF	Accident Tolerant Fuel
ASTRID	Advanced Sodium Technological Reactor for Industrial Demonstration
CEA	Commissariat à l'Energie Atomique (French Atomic Energy Commission)
CRADA	Cooperative Research and Development Agreement
CINDI	Characterization-scale Instrumented Neutron Dose Irradiation module
CINR	Consolidated Innovative Nuclear Research
DNB	departure from nucleate boiling
DOE	U.S. Department of Energy
EBR-II	Experimental Breeder Reactor II
FCRD	Fuel Cycle Research and Development
FFTF	Fast Flux Test Facility
GAIN	Gateway for Accelerated Innovation in Nuclear
HFEF	Hot Fuel Examination Facility
INL	Idaho National Laboratory
IRP	Integrated Research Project
ISTEP	Integrated Strategic Transient Experiment Plan
JAEA	Japan Atomic Energy Agency
LOCA	loss-of-coolant accident
MARCH	Minimal Activation Retrievable Capsule Holder
MFF	Mechanistic Fuel Failure
NASA	National Aeronautics and Space Administration
NEAMS	Nuclear Energy Advanced Modeling and Simulation
NEET	Nuclear Energy Enabling Technology
NEUP	Nuclear Energy University Program
NS&T	Nuclear Science & Technology
NSUF	Nuclear Science User Facilities
PIE	Post Irradiation Examination
POL	INL Policy document
RIA	Reactivity Initiated Accident
SETH	Separate Effects Test Holder module
SERTTA	Static Environment Rodlet Transient Test Apparatus
TITAN-C1	Transient Irradiation TerraPower Advanced Nuclear fuel, initial capsules tests
THOR	Temperature Heat-sink Overpower Response module
TREAT	Transient Reactor Test Facility
TWERL	TREAT Water Environment Recirculating Loop

1. FY18 ANNUAL TEST PLAN

FY18 will emphasize execution of the first experiment campaigns, projected to start as early as April of 2018. To ensure effective utilization of the reactor, a full experimental campaign is planned. The following table includes committed/concurrent experiments that represent an anticipated full utilization for the reactor for FY18. Contingent experiments will be available to achieve full reactor utilization in the event that the committed experiment scope is restrained or is achieved with less transients than currently anticipated.

This experimental regime is challenging for the first partial year of operations and will provide good operating experience, as well as a strong experimental base for future years.

Table 1. FY18 Reactor Utilization and Experiment Activities.

Experiment	Scope	Start-ups*
Committed Experiments		
ATF-3 Transient Prescription Studies	Development of transient prescriptions and energy deposition measurement address relevant transients for future water-bearing ATF RIA-type irradiations.	10
Narrow Pulse Width Testing	Development of transient prescriptions to determine minimum pulse width with current TREAT configuration.	10
LOCA Testing	Development of transient prescriptions to demonstrate capability to simulate LOCA conditions.	5
ATF-SETH, Fresh Fuel Test Series	ATF fresh fuel irradiations in an inert gas environment using the SETH capsules in the MARCH vehicle. Approximately five rodlets (one per capsule per test), at varying specimen energy levels.	15
IRP Instrument Testing	Measurement and testing with in-core instrumentation to validate testing in the MITR.	10
Radiography Requalification	Testing to restore Neutron Radiography capability. Includes qualifying state of the art digital equipment as well as qualifying radiographers.	10
Concurrent Advanced Instrumentation Testing		
In-Core Instrumentation	Measurement and testing with in-core instrumentation including on-line instrumentation, radiation sensors, fiber optic sensors, and evaluation of Linear Variable Differential Transducers for radiation environments.	Concurrent with other prescribed operations
Hodoscope Restoration	Restore the Hodoscope to operation	Concurrent with other prescribed operations
Contingent Experiments		
Physics Testing/ Benchmark	Continuation of reactor physics tests to re-validate the historic TREAT physics codes and further develop the new NEAMS multi-physics code suite, including advanced instrumentation testing and calibration	As schedule allows

*Approximate number of reactor start-ups for reactor safety, physics, calibrations, and experiments. This number will vary depending on final experiment and operating plans.

2. SUMMARY OF TRANSIENT EXPERIMENT PROGRAM CUSTOMERS

A description of the currently anticipated experiment customers is summarized below. This list is currently under development as customer's needs iterate experiment development times, and available funding. NASA and Homeland Security have also expressed interest, but specific test designs are still being developed at this time.

Advanced Light Water Reactor Fuel Testing

The current efforts are focused on supporting the Accident Tolerant Fuel (ATF) mission. However, there are multiple programs dependent on this experimental infrastructure and early test data, such as the FY16 separate effects IRP awarded to Utah State University and a potential industry led NSUF proposal to study fuel safety criteria for very high burnup fuel. The assumed scope at the beginning of the ATF project included three experiment types, however an additional experiment type was added using the MARCH vehicle resulting in four experiment campaigns prior to 2022:

- Fresh fuel MARCH static capsules (2018-2019)
- Fresh fuel Multi-SERTTA static capsules (2019-2020)
- Irradiated fuel in Super-SERTTA static capsules (2020-2021)
- Irradiated fuel in TWERL flowing water loops (2021-2022).

This testing was the primary schedule driver for the resumption of transient testing, and by default is the highest priority. This work directly supports multiple congressional milestones relating to accident tolerant fuel development.

Multi-Physics Code Validation

The primary work scope in this area is associated with codes capable of predicting the response of tightly coupled, multi-physics systems that are being developed under the NEAMS program. TREAT is an ideal platform for development, validation, and ultimately use of these codes. These codes are expected to accelerate the overall development life-cycle for advanced nuclear fuel technology. In-pile transient instruments and benchmark cases are being developed under various programs (IRP, NEUP, NSUF, and NEET).

The validation activities in the TREAT reactor will be conducted as follows:

- 2018-2020: Reactor response models will be validated through characterization of reactor behavior under prescribed transients
- 2018-2020: Reactor-experiment coupling models will be validated using experiment calibration test data

- 2019-TBD: Fuel performance models under transient conditions will be validated using experiment results.

Fast Reactor Fuels Testing

Fast reactor testing needs are being clarified through technical interaction with FCRD Advanced Fuels, TerraPower, CEA Astrid, JAEA fast reactor programs, and the GAIN initiative. It is clear there is significant need and interest in this area, but plans are not as well developed as the ATF program. TerraPower provided a conceptual test plan that is currently being refined under a CRADA for the TITAN-C1 test campaign:

- Phase 1 (2019-2023): Separate effects testing of advanced fuel concepts using the THOR module of the MARCH system.

- Phase 2 (2021-2025): Assessment of base fuel design in Mk IV Na Loop using fresh and archived pre-irradiated EBR-II and FFTF-MFF fuel pins

- Phase 3 (2024-2025): Assessment of BOR-60 irradiated fuel pins in Mk IV Na Loop.

Collaborators at CEA, who have a strong interest due to the ASTRID reactor fuel development efforts, have suggested similar strategies and timeframes.

Separate Effects Testing for Fuel Safety Science

A variety of separate effects studies on nuclear fuel behavior are possible with TREAT. Early high impact test designs are being developed through interaction with existing DOE program missions and future competitive awards through DOE Consolidated Innovative Nuclear Research (CINR) solicitations.

Evaluation of Transient Critical Heat Flux is an internal experiment that will be planned and conducted by INL staff. This experiment has very important elements relating to the fundamental understanding of physical properties and phenomena leading to departure from nucleate boiling (DNB), in addition to more accurately characterizing the heat transport under DNB conditions. This is of crucial interest to the fuels development and regulatory entities, and strong international interest has been expressed. Recent and ongoing studies being conducted under DOE and international funding using non-nuclear heating and advanced modeling and simulation have demonstrated that in-pile testing is necessary to fully investigate this behavior, which has significant impact on both reactor operations and safety.

In-Core Instrumentation Measurement and Testing

In-core instrumentation plays a crucial supporting role in the objectives of transient irradiation testing. The development and ultimate qualification of in-core instrumentation requires significant testing in the unique radiation environment that the TREAT facility provides. Frequent and flexible access to measurements in the TREAT facility reactor core is key to the success of in-core instrumentation, the transient testing experiments program, and the TREAT facility. These needs are also envisioned to support general in-pile instrumentation development beyond the specific goals of the transient testing programs.

The deployment of independent in-core instrumentation includes the following:

- Concurrent testing accompanying ongoing reactor operations including experiments with independent objectives;

- Instrumentation experiments with dedicated reactor prescriptions and support – likely to include international collaborators;
- Instrumentation supporting experiments described in other categories above and below.

3. FUNDING ASSUMPTIONS

The Transient Experimental Schedule proposed is reliant on FY18-22 funding. The reactor base operations are adequately funded under Integrated Facility Management. The scientific infrastructure capability funding needs are under development. Funding for experiments necessary to accomplish the ISTEP is described in POL-150, Pricing Policy for Transient Reactor Test Facility Irradiation Services.

The work scope described in the ISTEP reflects a developing transient testing program. As reactor operations and initiation of experiments approach, it is clear that the complexity and amount of internal and external interfaces will rapidly escalate. To ensure the appropriate management of the transient experiment program, it is recommended that a consolidated program structure be established. This program will systematically develop an integrated and detailed plan for all of these new activities to enable timely and efficient execution. The structure and process used for the other major NE programs provides a template for success in this area.

4. THE INTEGRATED STRATEGIC TRANSIENT EXPERIMENT PLAN

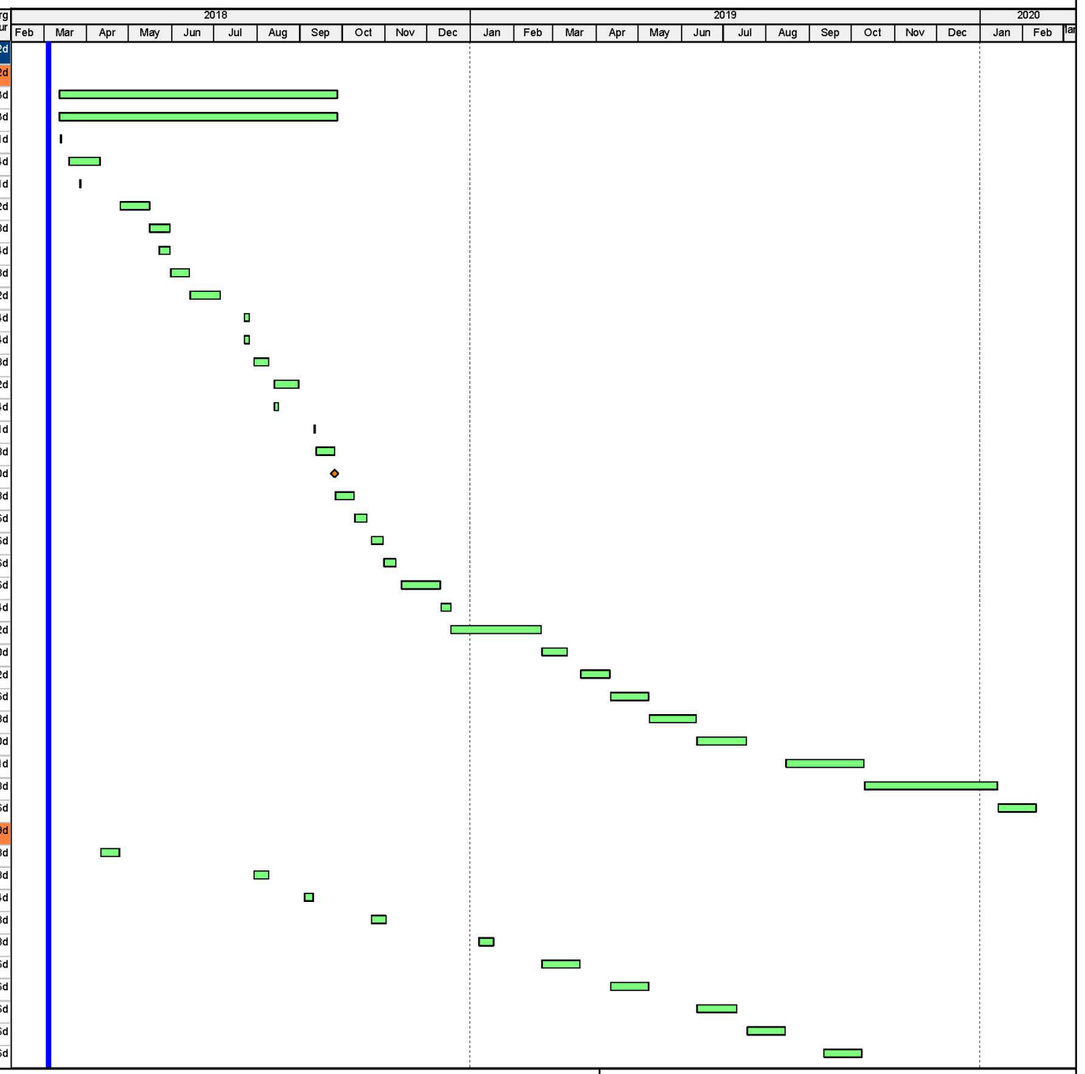
The ISTEP Reactor Utilization and Transient Experiment Schedule are on the following page. The Reactor Utilization Schedule is focused on TREAT reactor utilization, while the Transient Experiment Schedule integrates the projected experiments as noted in the Transient Experiment Programs including programmatic development, and associated required scientific and enabling infrastructure development.

The FY-18 ISTEP Reactor Utilization and Transient Experiment Schedule is mainly populated with tasks supporting ATF testing, TREAT physics testing, capability testing, and advanced instrumentation development. The ISTEP will be reviewed quarterly and priorities set by representatives from TREAT and NS&T. Current experiments are all managed through NS&T, thus priority conflicts are easily resolved. In the future if scheduling and prioritization becomes an issue, a TREAT Users Working Group will be established made up of representatives of the respective users including, NS&T, future science leads, TREAT Operations and Engineering, as well as MFC facilities that will set the schedule priorities.

5. SCHEDULE

ISTEP Reactor Utilization and Transient Experiment Schedule

Activity ID	Activity Name	Org Dur
LONG RANGE FORECAST		382d
NORMAL OPERATIONS		382d
E1195	ADVANCED IN-CORE INSTRUMENTATION (CONCURRENT TESTING DP-129)	113d
E1235	HODOSCOPE RECOVERY (CONCURRENT WITH FY18 REACTOR OPERATIONS)	113d
P1005	RADIOGRAPHY - FLUX MEASURE - GOLD FOIL*	1d
P1010	TREAT FUEL ASSEMBLY WORTH MEASUREMENTS* (4SS)	14d
P1025	RADIOGRAPHY - MULTI FOIL*	1d
E1100	ATF-3-1 TRANSIENT PRESCRIPTION TESTS (1SS, 5T)	12d
P1075	RADIOGRAPHY QUALIFICATION (5 SETS OF MULTIPLE SHOTS)	8d
P1070	REACTIVITY COMPUTER SO TEST - PREPARATIONS	4d
E1105	TEST ADVANCED INSTRUMENTATION WITH IRP CAPSULE EXPERIMENT IN M8 CAL (1SS, 4T)	8d
E1165	NARROW PULSE WIDTH TRANSIENTS (8T)	12d
E1185	LOCA SHAPED TRANSIENTS - PART I (2T)	4d
E1225	NEUTRON DETECTOR/OPTICAL FIBER SENSORS (CONCURRENT INSTRUMENTATION TESTING DP-129)	4d
E1130	RECONFIGURE CORE TO SUPPORT ATF TESTING IN MARCH SYSTEM	8d
E1115	CORE CHARACTERIZATION TO SUPPORT TESTING IN MARCH SYSTEM - (ROD WORTH, HEAT BALANCE, TL-1, TL-2, & TL-3)	12d
P1085	REACTIVITY COMPUTER SO TEST - VALIDATION	4d
P1235	RADIOGRAPHY SHOT FOR ATF SETH A TRANSIENT	1d
E1125	ATF SETH A TRANSIENT (1T)	8d
E1135	ATF SETH A TRANSIENT COMPLETE	0d
E1170	ATF SETH B TRANSIENT (1T)	8d
E1120	ATF SETH C TRANSIENT (1T)	6d
E1175	ATF SETH D TRANSIENT (1T)	6d
E1180	ATF SETH E TRANSIENT (1T)	6d
E1160	STEADY STATE IRRADIATIONS TO SUPPORT MATERIALS USING CINDI EXPERIMENTS/SIMULATIONS IN MARCH SYSTEM (LDRD)	16d
E1215	LOCA SHAPED TRANSIENTS - EXTENDED MODE PART II (2T)	4d
P1020	TEMPERATURE PROFILE*	32d
P1015	FISSION RATE MAP	10d
E1140	NEET INSTRUMENT TESTING IN MARCH SYSTEM WITH MIMIC MODULE	12d
E1145	MULTI-SERRTA CALIBRATION	16d
E1150	TITAN TESTING IN MARCH SYSTEM WITH THOR MODULE	18d
P1030	FISSION PROFILE*	20d
P1035	KINETIC PARAMETER MEASUREMENT*	31d
P1040	TRANSIENT CHARACTERIZATION (TEMP LIMIT TRANSIENT, TRANS CLIPPING, LOCA, UTOP, UTOP/ULOF, FLATTOP, BWR POWER)*	48d
P1065	TEMPERATURE COEFFICIENT MEASUREMENT*	16d
PLANT MAINTENANCE		299d
M1015	MONTHLY, QUARTERLY, & ANNUAL PMS (2ND QTR 2018)**	8d
M1025	ANNUAL TECH. SPEC. CALIBRATIONS - PM (RTS, DMT, Comp and Control Rod, &ARCS) - 2018	8d
M1020	MONTHLY, QUARTERLY, & ANNUAL PMS (3RD QTR 2018)**	4d
M1030	MONTHLY, QUARTERLY, & ANNUAL PMS (4TH QTR 2018)**	8d
M1040	CRANE AND HOIST ANNUAL INSPECTIONS - PMS (2019)	8d
M1035	MONTHLY, QUARTERLY, & ANNUAL PMS (1ST QTR 2019)**	16d
M1045	MONTHLY, QUARTERLY, & ANNUAL PMS (2ND QTR 2019)**	16d
M1050	MONTHLY, QUARTERLY, & ANNUAL PMS (3RD QTR 2019)**	16d
M1055	ANNUAL TECH. SPEC. CALIBRATIONS - PM (RTS, DMT, Comp and Control Rod, &ARCS) - 2019	16d
M1060	MONTHLY, QUARTERLY, & ANNUAL PMS (4TH QTR 2019)**	16d



Actual Work
Remaining Work
Critical Remaining Work
Milestone
% Complete

NOTES:
1 - *These activities can be delayed to accommodate developing customers.
2 - **These activities include "Plant Health Improvements" as they become ready for implementation.

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Page - 1 of 1