Target Diagnostic Timing Manager

W. J. ARMSTRONG, J. C. PUTH, and R. ROMBAUT
University of Rochester, Laboratory for Laser Energetics

Current timing-management tools

- Target diagnostic timing manager (TDTM) stores reference information, calculates, and lists desired Δt for each diagnostic
- Values are calculated for each diagnostic as configured in the shot request form (SRF)
- The timing checker spreadsheet displays timing monitor scope traces, measures the on-shot Δt, and compares it to the calculated value

Phase I data flow

1. SRF
   - Diagnostic delays
   - Shot time
   - Reference delay
   - TIM waveform
2. TDTM Database
   - TIM delays
   - Reference delay
3. Admin
   - TIM delays
   - Reference delay
4. TDTM GUI
   - ESO
   - TIM delays
   - Reference delay
5. ESO
   - TIM delays
   - Reference delay
6. TIM
   - TIM delays
   - Reference delay

Requirements

- Measure firing times of TIM-based diagnostics to less than 100 ps
- Store configuration data in easy to update database
- Archive timing monitor scope traces in hierarchical data format (HDF) files
- Collect and archive data on shot
- Allow for test firing of diagnostics without “burning a shot”
- Experimental system operator (ESO) client to accurately time diagnostics using TDTM
- Provide a visual display (e.g., plot/chart) of the scope traces from test fires and target shots
- Provide a dedicated client for TIM-based HTS channels

TDTM is operational on OMEGA and EP

- Calculates the expected Δt and HTS delay values
- Selects the correct timing parameters based on SRF configuration
- Calculates HTS delay values correctly and updates them as desired

TDTM features summary

- Previous procedures used two Excel spreadsheets and manually repetitive, error-prone steps to determine the proper timing; TDTM will replace the spreadsheets with a single automated application, controlled by the LLE Software Development Group
- Phase I has replaced the delay calculator spreadsheet, establishing proper timing for diagnostics to acquire the expected data on a target shot (2014)
- Phase II has replaced the separate diagnostic timing check (DTC) application, incorporating its functions and all timing data acquisition and archiving into TDTM (2015)
- Phase III will replace the timing checker spreadsheet, automating some timing-analysis functions and creating a mechanism for easy storage and retrieval of data
- TDTM has been designed to automate repetitive steps and use database tables to facilitate retrieval of historical information

TDTM software status

- Phase I is operational at the OMEGA and OMEGA EP ESO stations and has replaced the weekly “delay calculator” spreadsheet
- Phase II has replaced the “autolaunch” script and “DTC” application
- Phase III (future) will automatically update the “measured Δt” value from the timing scope and replace the “timing checker” spreadsheet
- A Microsoft-Access application has been created for Omega XOPS to maintain administrative tables in the database
- SRF diagnostic setup sheets have been changed to include standoff distances, in cm, for all timed diagnostics for TDTM x-ray time-of-flight calculations
- Updates are database driven; no code changes are required
Omega diagnostic timing

Legend
EMS: end-mirror structure
HTS: Hardware Timing System
PLAS: path-length adjustment system
FASP: F-stage alignment sensor package
FCC: frequency-conversion crystal
HED: harmonic energy diagnostic
TCC: target chamber center
Diagnostic timing—HTS, fiducial, and $t_0$

• Diagnostic trigger timing is controlled by the HTS and measured against a fiber-delivered laser fiducial pulse

• The HTS delivers synchronized trigger pulses to the OMEGA laser–driver line, amplifiers, and all target diagnostics
  – ten-inch manipulator (TIM)-based diagnostic triggers are either transistor–transistor logic (TTL) or amplified TTL pulses at $t_0$, $t_0 - 10$ s, or 0.1 Hz (continuous, every 10 s)
  – trigger delays are variable in 100-ps increments

• The fiducial laser pulse is generated from the OMEGA seed pulse to ensure stable timing
  – the fiducial pulse consists of eight peaks spaced at 548 ps
  – 1$\omega$, 2$\omega$, and 4$\omega$ (1054, 527, and 263 nm) fiducial signals are available
  – the timing monitor system uses the IR fiducial, directed into a photodiode, to generate oscilloscope reference pulses at a fixed time relative to $t_0$

• The nominal time that the main OMEGA drive beams reach the target is defined as $t_0$
  – beam timing can be varied by shifting driver timing or changing the path length of individual beams
  – time changes are specified in nanoseconds relative to $t_0$
  – the P510 streak cameras measure on-shot pulse timing versus the green fiducial
Current timing-management tools

- Target diagnostic timing manager (TDTM) stores reference information, calculates, and lists desired $\Delta t$ for each diagnostic.

- Values are calculated for each diagnostic as configured in the shot request form (SRF).

- The timing checker spreadsheet displays timing monitor scope traces, measures the on-shot $\Delta t$, and compares it to the calculated value.
TDTM features summary

- Previous procedures used two Excel spreadsheets and manually repetitive, error-prone steps to determine the proper timing; TDTM will replace the spreadsheets with a single automated application, controlled by the LLE Software Development Group.

- Phase I has replaced the delay calculator spreadsheet, establishing proper timing for diagnostics to acquire the expected data on a target shot (2014).

- Phase II has replaced the separate diagnostic timing check (DTC) application, incorporating its functions and all timing data acquisition and archiving functions into TDTM (2015).

- Phase III will replace the timing checker spreadsheet, automating some timing-analysis functions and creating a mechanism for easy storage and retrieval of data.

- TDTM has been designed to automate repetitive steps and use database tables to facilitate retrieval of historical information.
Requirements

- Measure firing times of TIM-based diagnostics to less than 100 ps
- Store configuration data in easy to update database
- Archive timing monitor scope traces in hierarchical data format (HDF) files
- Collect and archive data on-shot
- Allow for test firing of diagnostics without “burning a shot”
- Experimental system operator (ESO) client to accurately time diagnostics using TDTM
- Provide a visual display (e.g., plot/chart) of the scope traces from test fires and target shots
- Provide a dedicated client for TIM-based HTS channels
Phase I data flow

1. **Principal Investigator**
   - Diagnostic delays
     - Start time
     - Nose/standoff
     - Sweep speed

2. **Admin**
   - Static delays
     - Intrinsic camera
     - TIM cable

3. **TIM’s only**
   - TIM’s only HDF file (timing data)

4. **ESO**
   - ESO analyzes data from DTC, null template, or target shot shot results
   - ESO saves measured $\Delta t^*$
   - ESO saves measured $\Delta t$
   - Measured $\Delta t$ from analysis

5. **TDTM GUI***
   - Reference delay

6. **HTS**
   - ESO updates HTS with desired delay* for each diagnostic
   - ESO updates HTS with desired delay* for each diagnostic
   - ESO selects request ID (RID)

7. **OIP****
   - Take shot

**Terms**
- Reference delay = HTS delay – measured $\Delta t$
- Calculated $\Delta t$ = SRF delays + static delays
- Desired delay = reference delay + calculated $\Delta t$

---

*GUI: graphical user interface
**OIP: OMEGA intercommunication protocol
TDTM TIM diagnostics GUI

- Display timing details
- SRF delays + static delays
- Manually entered timing offset based on data analysis
- HTS move required to put TIM at "timed position"
- Larger values cue ESO to run DTC or null template
- Conduct a simulated shot to check diagnostic timing
- List of unshot RID’s for the day
- OIP RID auto loaded if no RID selected
- Green and active when OIP RID is loaded and all TIM’s are timed
- Display individual crate status and allow reset
- Green if all crates are OK
- Red if any crate has an error
- Yellow if any crate is resetting
TDTM is operational on OMEGA and EP

- Calculates the expected $\Delta t$ and HTS delay values
- Selects the correct timing parameters based on SRF configuration
- Calculates HTS delay values correctly and updates them as desired
TDTM software status

- Phase I is operational at the OMEGA and OMEGA EP ESO stations and has replaced the weekly “delay calculator” spreadsheet
- Phase II has replaced the “autolaunch” script and “DTC” application
- Phase III (future) will automatically update the “measured $\Delta t$” value from the timing scope and replace the “timing checker” spreadsheet
- A Microsoft-Access application has been created for Omega XOPS to maintain administrative tables in the database
- SRF diagnostic setup sheets have been changed to include standoff distances, in cm, for all timed diagnostics for TDTM x-ray time-of-flight calculations
- Updates are database driven; no code changes are required