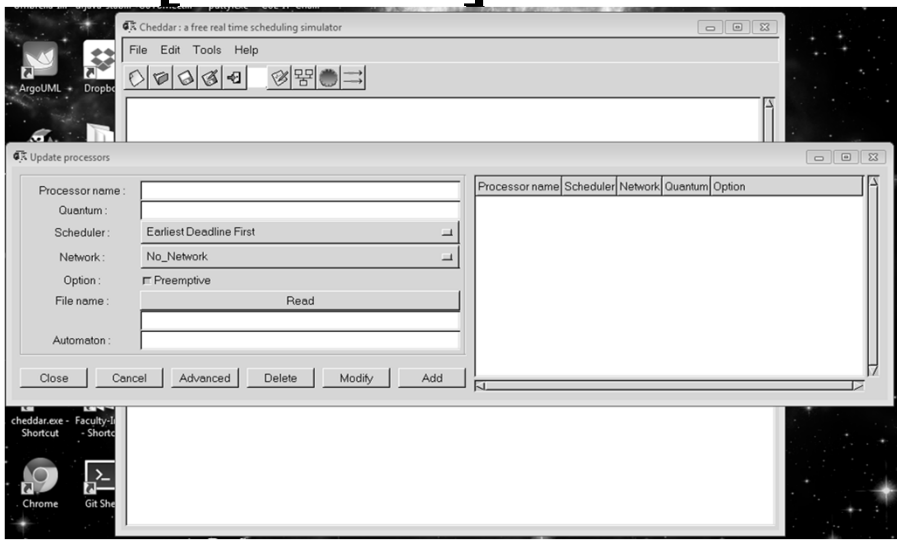
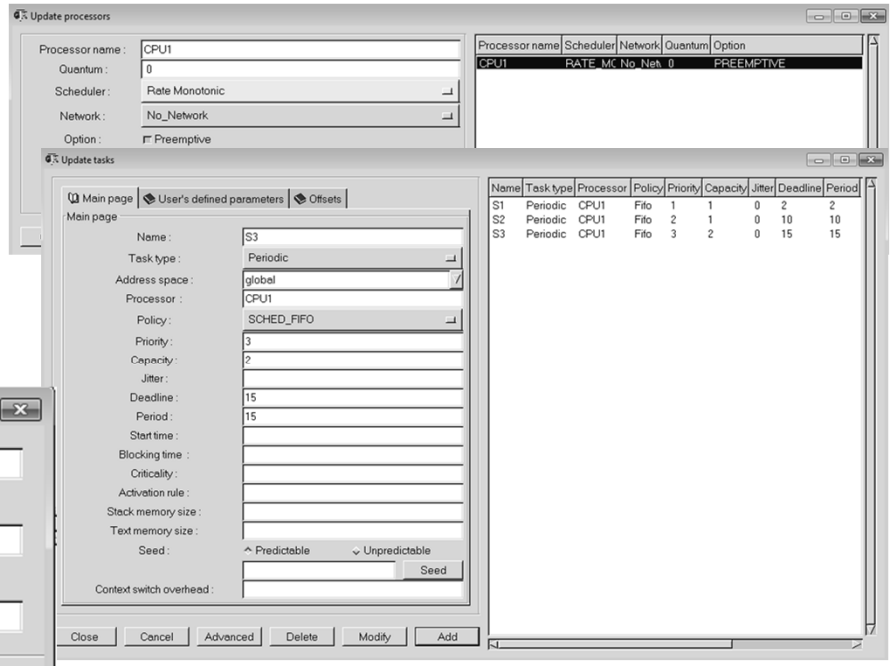
CEC 450
Real-Time Systems

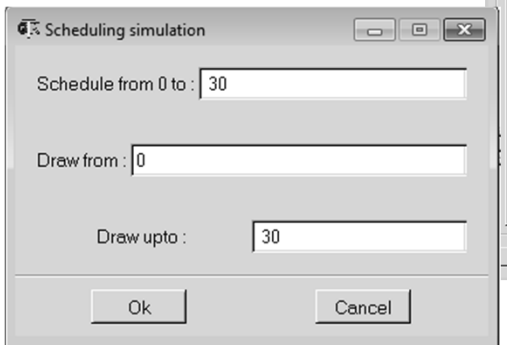
Lecture – RM Analysis Examples with Cheddar

Using Cheddar [Basics]

- Download for Windows [here]
- Use “Edit” to Start
- Start with Update Processors
- Add it
- Update Address Spaces, Add it
- Update Tasks, Add $S_1 \ldots S_n$
- Note Cheddar Runs over LCM

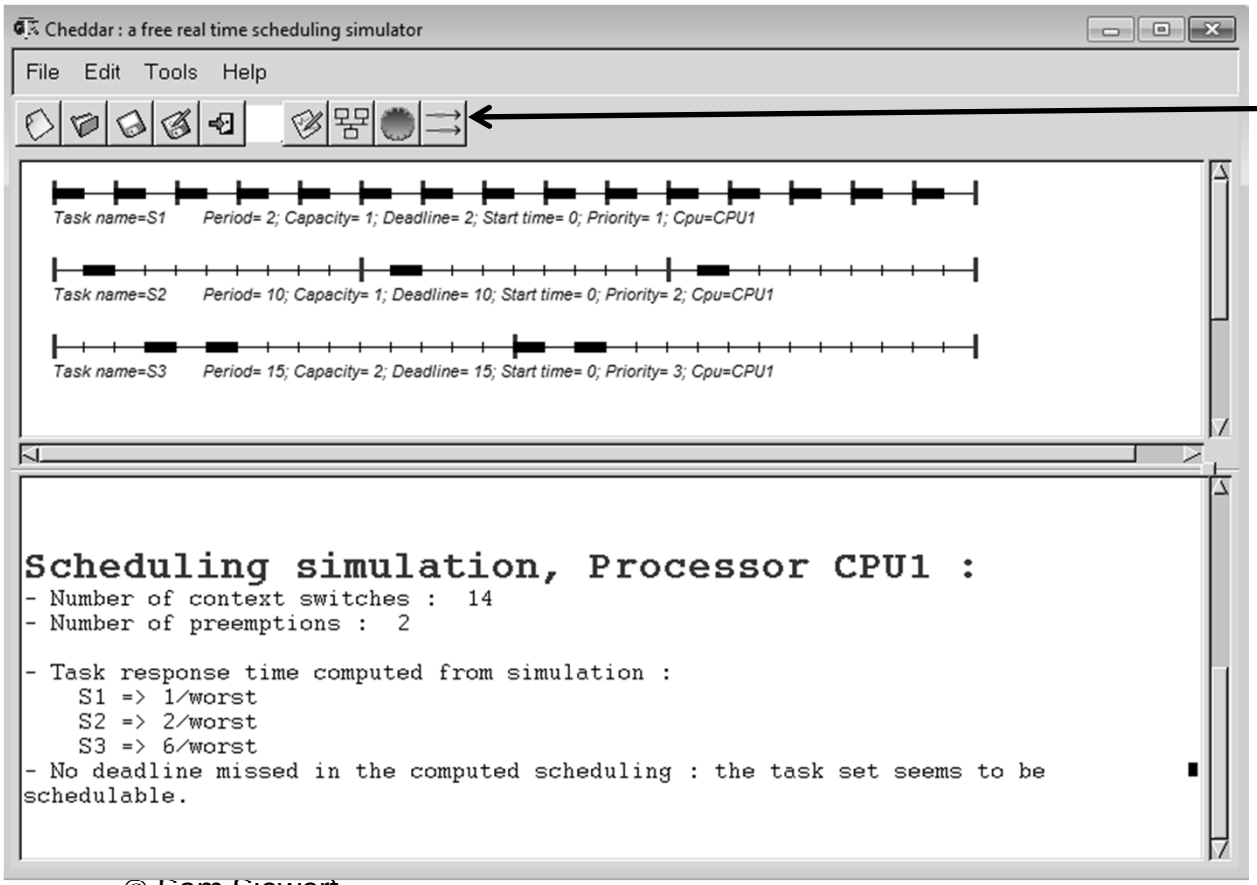






Simulation

- Hit Simulation button to Start
- Calculates LCM, Runs, Produces Timing Diagram and Summary



Simulation Button

Timing Diagram

Summary – Note the conclusion “seems”

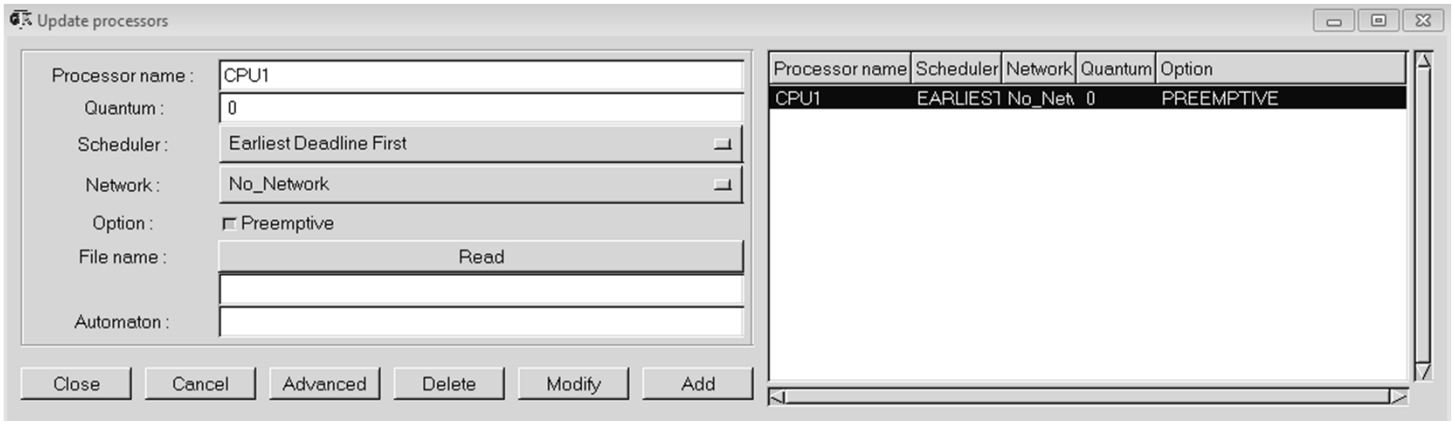
Feasibility Test

- Hit Feasibility button to Test
- For RM Policy, Cheddar Uses the RM LUB
- For All Policies, Cheddar Provides Worst-Case Analysis

RM Policy Example

```
Scheduling feasibility, Processor CPU1 :
1) Feasibility test based on the processor utilization factor :

- The base period is 30 (see [18], page 5).
- 8 units of time are unused in the base period.
- Processor utilization factor with deadline is 0.73333 (see [1], page 6).
- Processor utilization factor with period is 0.73333 (see [1], page 6).
- In the preemptive case, with RM, the task set is schedulable because the processor utilization factor 0.73333 is equal or less than 0.77976 (see [1], page 16, theorem 8).


2) Feasibility  test based on worst case task response time :

- Bound on task response time :  (see [2], page 3, equation 4).
    S3 => 6
    S2 => 2
    S1 => 1
- All task deadlines will be met : the task set is schedulable.
```

- Change Update Processors to EDF



Run Again with EDF to Compare

- Priorities are Dynamic, So Just Change Processor Scheduler Policy, Re-Run Simulation and Feasibility

```
Scheduling feasibility, Processor CPU1 :
1) Feasibility test based on the processor utilization factor :

- The base period is 30 (see [18], page 5).
- 8 units of time are unused in the base period.
- Processor utilization factor with deadline is 0.73333 (see [1], page 6).
- Processor utilization factor with period is 0.73333 (see [1], page 6).
- In the preemptive case, with EDF, the task set is schedulable because the processor utilization factor 0.73333 is equal or less than 1.00000 (see [1], page 8, theorem 2).

2) Feasibility  test based on worst case task response time :

- Bound on task response time :
    S1 => 1
    S2 => 8
    S3 => 13
- All task deadlines will be met : the task set is schedulable.
```

Note EDF

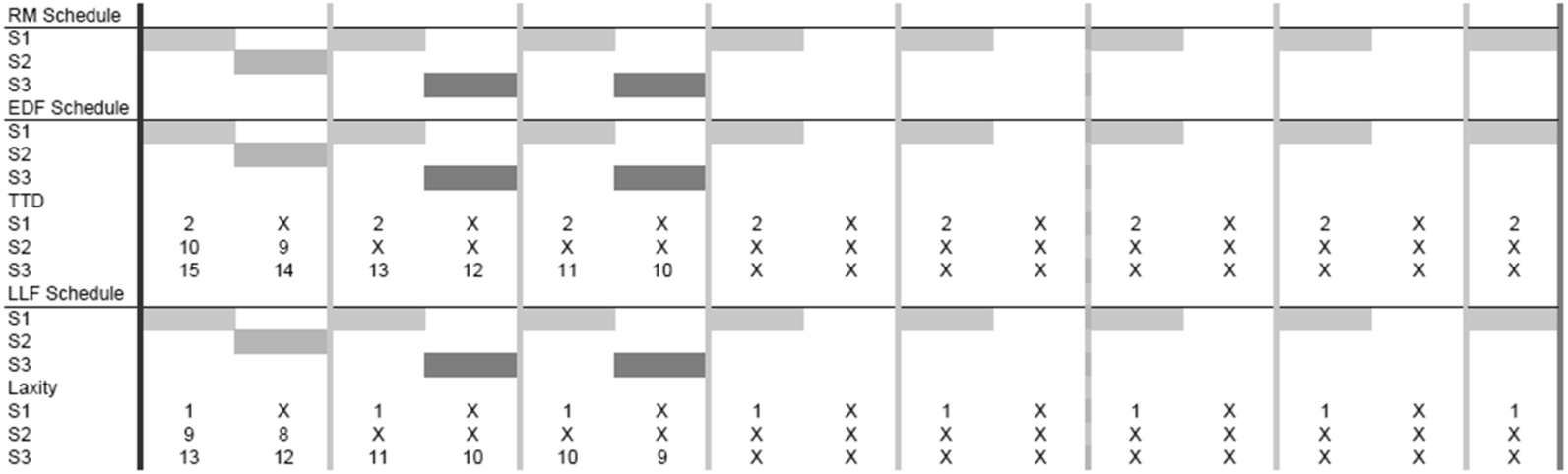
```
Scheduling feasibility, Processor CPU1 :
1) Feasibility test based on the processor utilization factor :

- The base period is 30 (see [18], page 5).
- 8 units of time are unused in the base period.
- Processor utilization factor with deadline is 0.73333 (see [1], page 6).
- Processor utilization factor with period is 0.73333 (see [1], page 6).
- In the preemptive case, with LLF, the task set is schedulable because the processor utilization factor 0.73333 is equal or less than 1.00000 (see [7]).

2) Feasibility  test based on worst case task response time :

- Bound on task response time :
    S1 => 1
    S2 => 8
    S3 => 13
- All task deadlines will be met : the task set is schedulable.
```

Note LLF

Example-0 Timing Diagram

- RM, EDF, LLF Succeed, 73.33% CPU Utilization

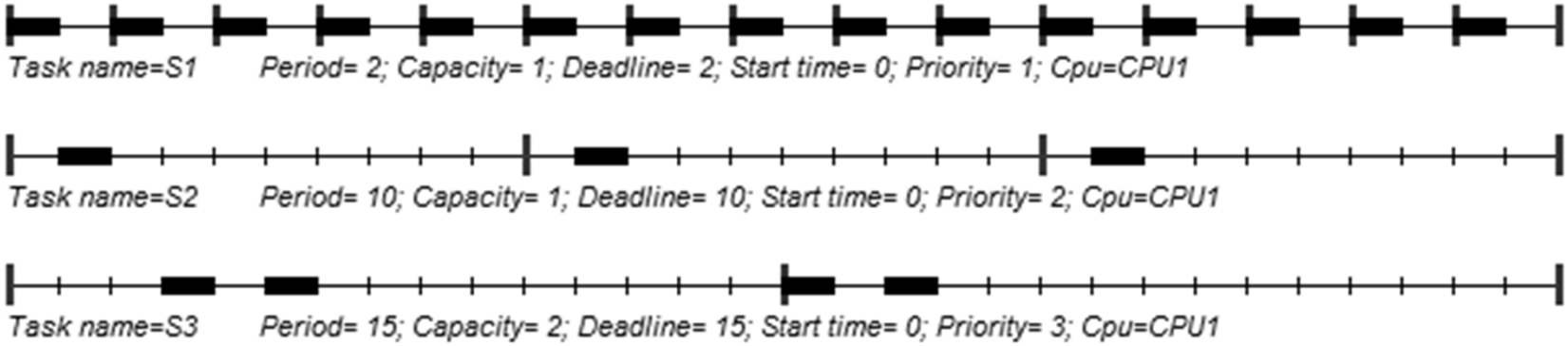
Example 0	T1	2	C1	1	U1	0.5	LCM =	30
	T2	10	C2	1	U2	0.1		
	T3	15	C3	2	U3	0.133333	Utot =	0.733333




```
Scheduling simulation, Processor CPU1 :
- Number of context switches :  14
- Number of preemptions :  2

- Task response time computed from simulation :
    S1 => 1/worst
    S2 => 2/worst
    S3 => 6/worst
- No deadline missed in the computed scheduling : the task set seems to be schedulable.
```

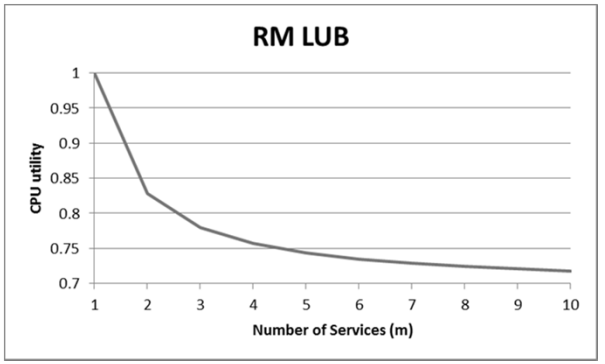
Example-0 Cheddar RTSS

- Download Cheddar RT Analyzer, Example-0 XML




```
Scheduling feasibility, Processor CPU1 :
1) Feasibility test based on the processor utilization factor :

- The base period is 30 (see [18], page 5).
- 8 units of time are unused in the base period.
- Processor utilization factor with deadline is 0.73333 (see [1], page 6).
- Processor utilization factor with period is 0.73333 (see [1], page 6).
- In the preemptive case, with RM, the task set is schedulable because the processor
utilization factor 0.73333 is equal or less than 0.77976 (see [1], page 16, theorem 8).


2) Feasibility  test based on worst case task response time :

- Bound on task response time :  (see [2], page 3, equation 4).
    S3 => 6
    S2 => 2
    S1 => 1
- All task deadlines will be met : the task set is schedulable.
```

$$U = \sum_{i=1}^{m} (Ci/Ti) \leq m(2^{\frac{1}{m}} - 1)$$



Example-1 Timing Diagram

- RM FAILS, EDF, LLF Succeed, 98.57% CPU Utilization

Example 1	T1	2	C1	1	U1	0.5	LCM =	70		
	T2	5	C2	1	U2	0.2				
	T3	7	C3	2	U3	0.285714	Utot =	0.985714		
RM Schedule										
S1							????????			
S2						????????				
S3								LATE		
EDF Schedule										
S1										
S2										
S3										
TTD										
S1	2	X	2	X	2	X	2	X	2	X
S2	5	4	X	X	X	5	4	3	X	X
S3	7	6	5	4	3	2	X	7	6	5
LLF Schedule										
S1										
S2										
S3										
Laxity										
S1	1	X	1	X	1	X	1	X	1	X
S2	4	3	X	X	X	4	3	2	X	X
S3	5	4	3	2	2	1	X	5	4	3

```
Scheduling simulation, Processor CPU1 :
- Number of context switches :  68
- Number of preemptions :  10

- Task response time computed from simulation :
    S1 => 1/worst
    S2 => 2/worst
    S3 => 8/worst ,  missed its deadline (deadline =  7 ; completion time =  8)
- Some task deadlines will be missed : the task set is not schedulable.
```

Example-1 Cheddar RTSS

- RM Not Feasible by LUB or by Inspection over LCM

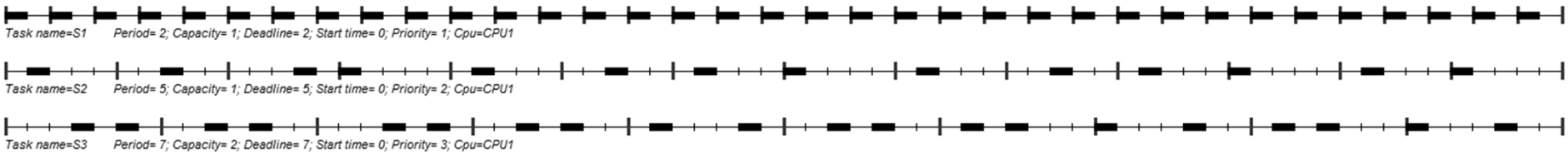
```
Scheduling feasibility, Processor CPU1 :
1) Feasibility test based on the processor utilization factor :

- The base period is 70 (see [18], page 5).
- 1 units of time are unused in the base period.
- Processor utilization factor with deadline is 0.98571 (see [1], page 6).
- Processor utilization factor with period is 0.98571 (see [1], page 6).
- In the preemptive case, with RM, we can not prove that the task set is schedulable
is more than 0.77976 (see [1], page 16, theorem 8).


2) Feasibility  test based on worst case task response time :

- Bound on task response time :  (see [2], page 3, equation 4).
    S3 => 8,  missed its deadline (deadline =  7)
    S2 => 2
    S1 => 1
- Some task deadlines will be missed : the task set is not schedulable.
```

- EDF?

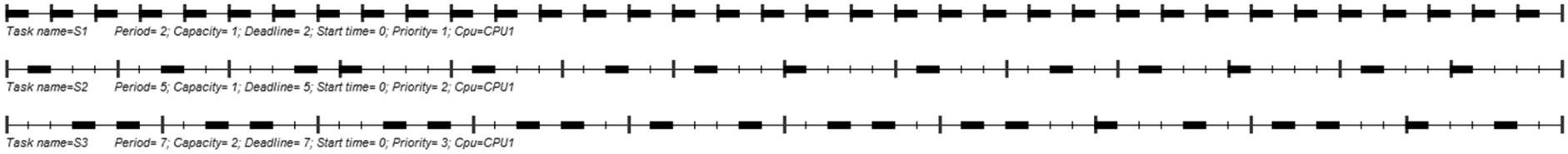
```
Scheduling feasibility, Processor CPU1 :
1) Feasibility test based on the processor utilization factor :

- The base period is 70 (see [18], page 5).
- 1 units of time are unused in the base period.
- Processor utilization factor with deadline is 0.98571 (see [1], page 6).
- Processor utilization factor with period is 0.98571 (see [1], page 6).
- In the preemptive case, with EDF, the task set is schedulable because the processor utilization factor 0.98571 is equal or less
1.00000 (see [1], page 8, theorem 2).


2) Feasibility  test based on worst case task response time :

- Bound on task response time :
    S1 => 1
    S2 => 4
    S3 => 6
- All task deadlines will be met : the task set is schedulable.
```

Example-1 Cheddar RTSS

- EDF Simulation over LCM of 70



- LLF Simulation over LCM of 70



- Worst Case Feasibility Test
  - Fixed Priority (RM Policy) FAILS LUB and WC Feasibility Test (Scheduling Point or Completion Test)
  - Dynamic Priority Succeeds by Two Methods

Review Remaining Examples

- http://mercury.pr.erau.edu/~siewerts/cec450/documents/Timing_Diagrams/
- As Noted in Liu and Layland, Static Priority Policy May Not be Feasible in Cases where Dynamic Priority Policy is Feasible
- Are Feasibility and Safety Synonymous?
- Is it Wise to have Zero Margin?
- Have We Accounted for Context Switch Overhead and ISR Latency?

Cheddar References

- Help, Scheduling References
- References Used to Build Cheddar – Here
- General References - Here