U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

SAND Number 2015-xxxP

SAND2015-7540PE

GDP-Based Economic Model for MACCS Nuclear Accident Offsite Consequence Estimation

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Sandia National Laboratories

April 21, 2015

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Overview

- Goals for alternative MACCS economic model
- Regional Economic Accounting tool (REAcct) overview
  - Input-Output Modeling
  - GDP loss estimation
  - Data
- GDP loss estimation in MACCS-REAcct model
  - Parameters and assumptions
  - GDP loss estimation
    - Aggregation over time and space
    - Treatment of partially affected counties

Alternative Economic Model Goals

- Improve business disruption components of MACCS economic model
- Enable impact estimation by industry on the county level
- Enable consistent application of Input-Output methodology
- Update the model to use most recent data
- Enable continuous updates

REAcct Overview

- Employs Input-Output methodology, based on inter-industry commodity flows
- Uses geographic extent of disruption to estimate GDP losses
  - By industry
  - By county
- Uses RIMS II multipliers for indirect losses
- Uses Bureau of Economic Analysis (BEA) and U.S. Census Bureau data

Input-Output Methodology

- Represents flow of products between sectors of economy based on actual transactional data
- Linear, allows fast computation, analytically tractable
- Generally uses linear fixed proportions production functions
- Effects of local changes to the regional or national levels estimated using multipliers from the Regional Input-Output Modeling System (RIMS II)

Input-Output History

- Developed starting in 1930s by V. Leontief (Harvard, NBER)
- Represents aggregated transactions in economy
- Used extensively for estimating consequences of accidents and disasters, such as earthquakes and hurricanes
- Used for economic planning, on local, regional, and national levels

Input-Output Prevalence and Uses

- Incorporated into national accounting of many developed countries (USA, UK, EU, Japan…)
- Data is readily available
- Employed by:

DHS, FEMA, Census Bureau, DOE, DoD, Federal Reserve, Beareau of Economic Analysis, Department of Labor, EPA, US Corpos of Engineers, HPA (UK, COCO-2 – economic consequences model)

REAcct Uses

- DHS (NISAC):
  - Since 2004, used for all category 3 or above hurricanes
  - Hurricane swath analysis to enable future planning and response
  - Wildfires
  - Floods
  - BP Oil Spill
- SUMMIT (DHS S&T): used by FEMA for NLE12 and 2013 Moore Tornado

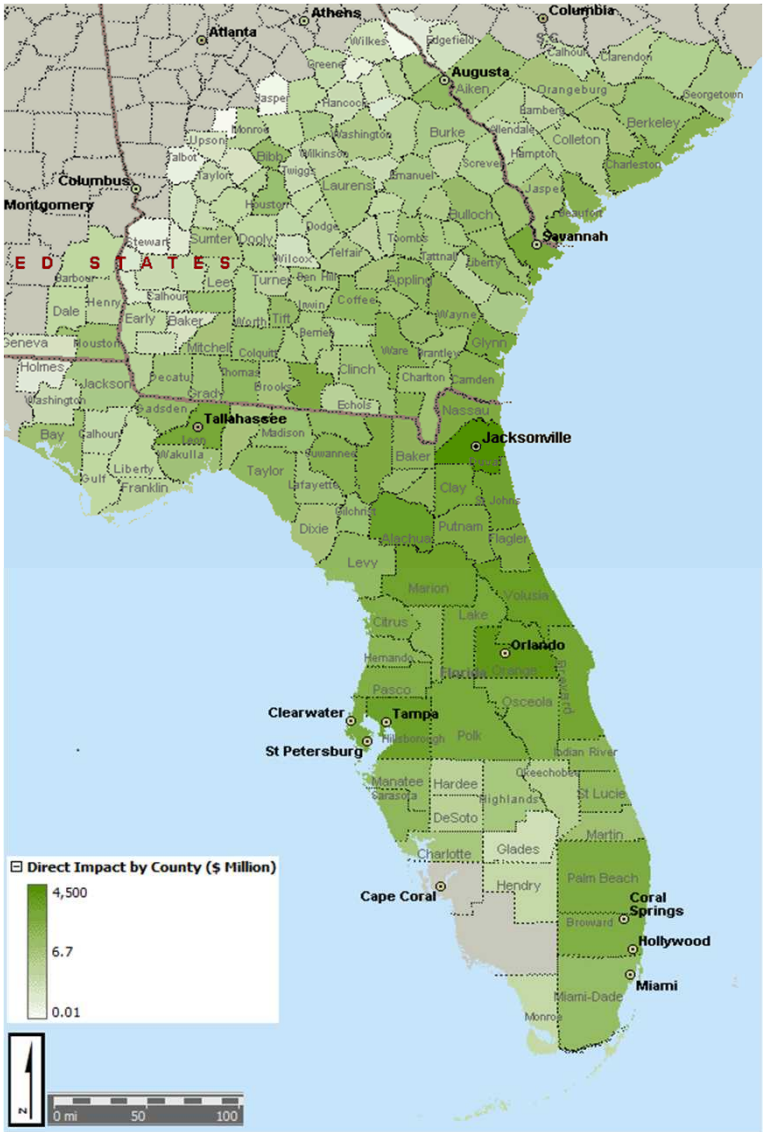
REAcct Fundamentals

- Estimates direct GDP reductions for each industry in the affected area
- Calculates indirect impacts on the national scale impacts using the BEA's RIMS II multipliers
- County–level, data and results
- Partially automated for ad-hoc disruption areas
- Takes GIS disruption shapes as inputs. Computes rapidly

REAcct Analysis

- A typical analysis includes:
  - Definition of the affected area
  - Calculation of GDP losses by industry for each county
  - Summation across all industries and counties and application of the RIMS II multipliers to calculate the national impacts

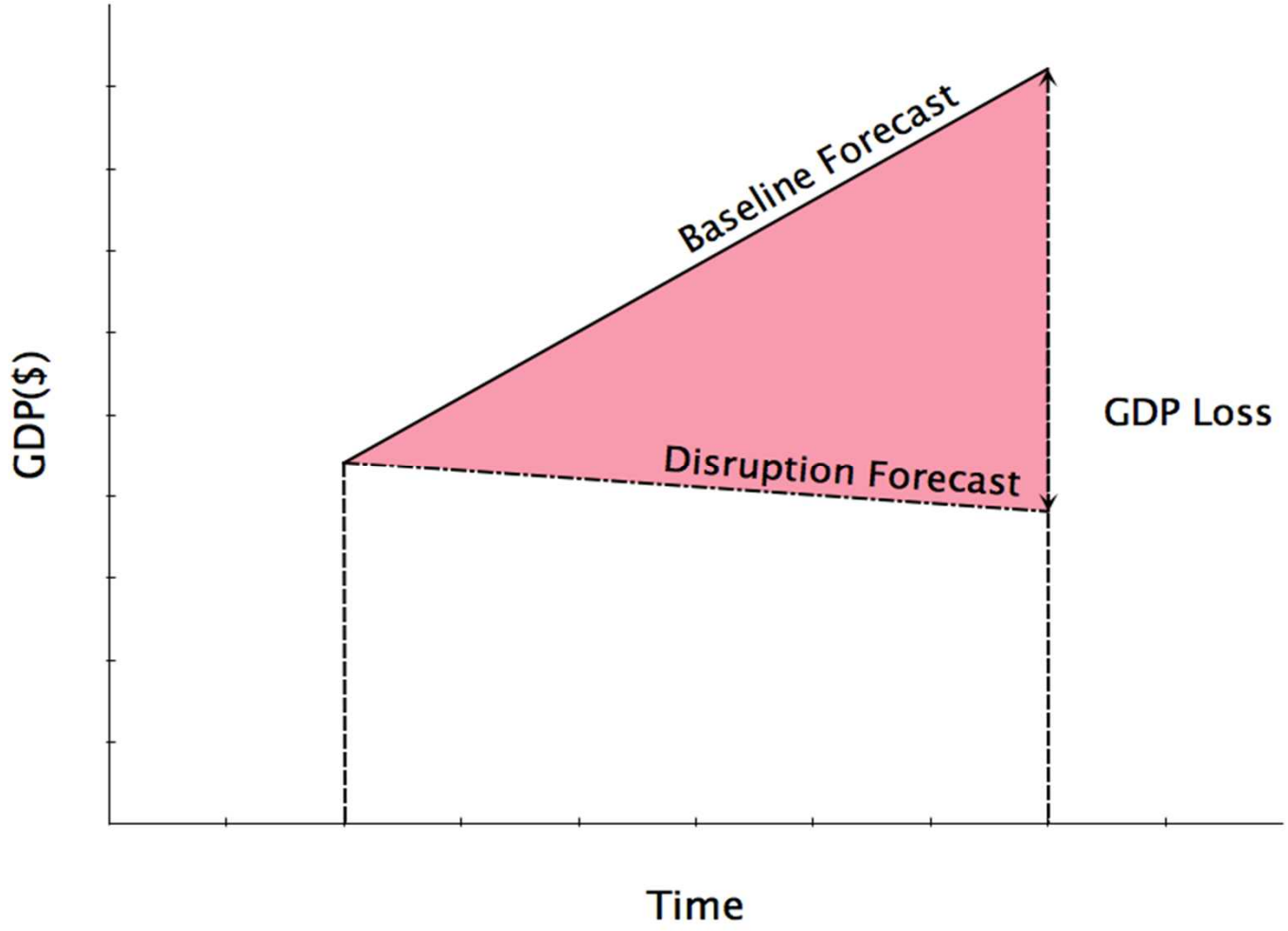
REAcct – Hurricane Example



REAcct Data

- BEA, U.S. Census Bureau
  - US Annual Output
  - US Employment
  - RIMS II Multipliers
  - County private industry employment
  - County government employment

Impact Estimation



Estimating Long-Term Impacts

- Estimation of long-term impacts requires answering following questions:
  - For how long to calculate the impacts when the area is abandoned?
  - How to estimate the future years' GDP?
  - What are appropriate discount rates?

GDP Calculation Parameters

- GDP growth rate
  - How to estimate GDP in future years?
- Loss calculation timeframe
  - Duration of GDP losses?
- Social discount rate
  - How much do we value future as compared to now?
- All parameters can be changed by users within certain bounds

Parameter Values and Bounds

	Real GDP Growth Rates (%)	Loss Calculation Duration (years)	Social Discount Rate (%)
Default value	3.3	10	3
Lower bound	1	2	1
Upper bound	8	30	8

Sources: historic data (US GDP growth rates (BEA), duration of recessions), existing literature (social discount rate, loss calculation duration (COCO-2)), government policies and circulars (OMB Circular A-94)

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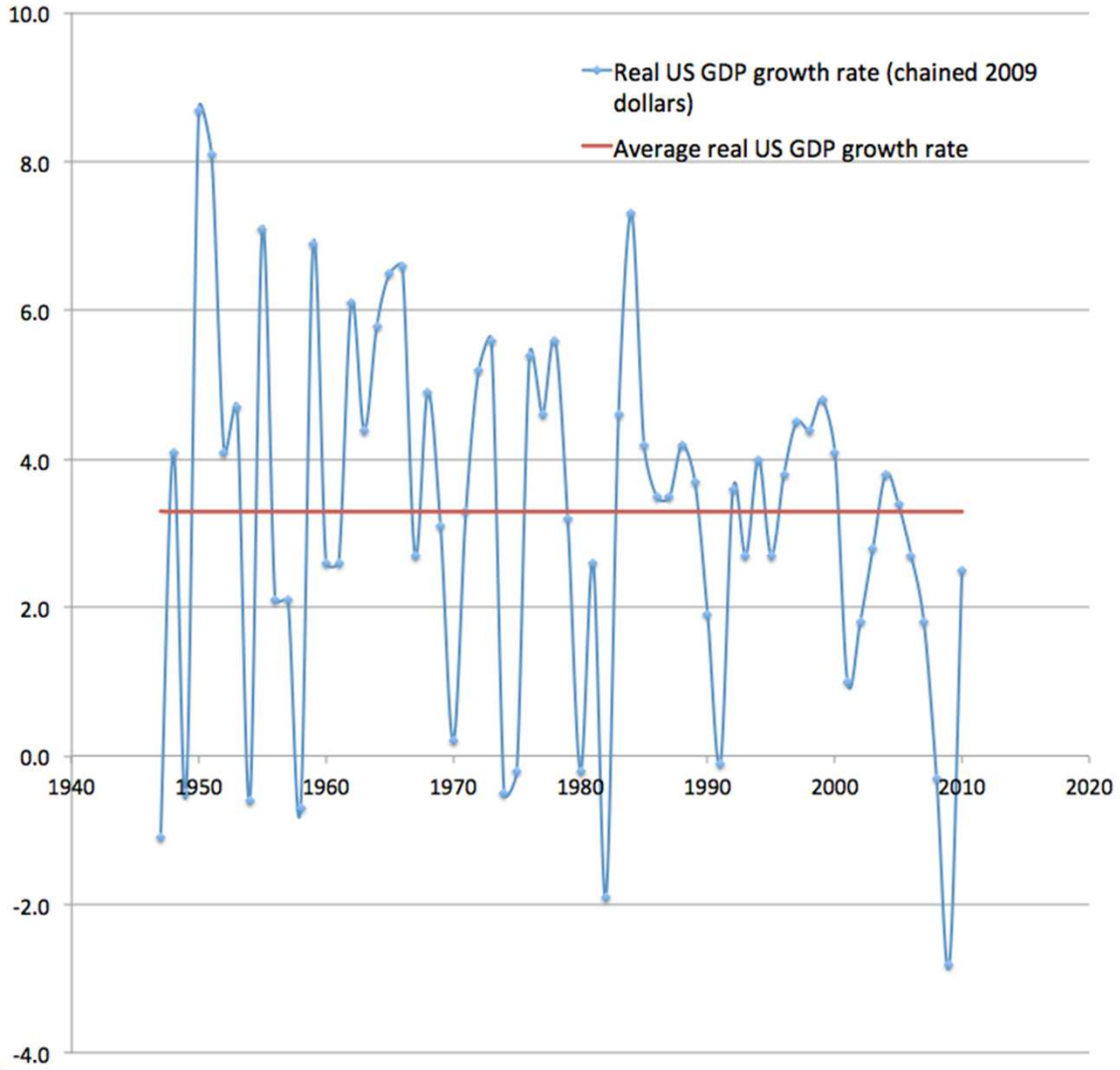
BNE1 Default Social Discount Rate is 3.0%

Bixler, Nathan E, 11/25/2013

Real GDP % Change over Time



Long-term Impacts Assumptions

- Do not include adaptation
- Do not include long-term structural change
- Do not include downstream impacts

Impact Estimation Workflow

- WinMACCS
  - Specify scenario parameters: affected area loss duration
  - Retrieve the annual GDP data from REAcct
  - Aggregate the REAcct data over time for the entire affected area taking into account the scenario parameters
- REAcct
  - Provide the annual GDP and employment data at the county and national levels for MACCS calculation

Direct Annual GDP Loss Calculation (REAcct)

- Direct annual GDP loss for each industry and county

$$gdp_{i,r}^{d} = \frac{Y_i^{US}}{E_i^{US}} E_i^{r}$$

Where

- d – direct, r – region (county), i – sector
- Y – annual GDP, E - employment

Total Annual GDP Loss Calculation (REAcct)

Direct annual GDP loss for the entire area and all industries

$$gdp = \sum_{r}^{R} \sum_{i}^{I} \frac{Y_i^{US}}{E_i^{US}} E_i^r m_i^r$$

Total GDP loss is estimated by multiplying the direct GDP losses by the RIMS II multipliers

$$gdp^d = \sum_{r}^{R} \sum_{i}^{I} \frac{Y_i^{US}}{E_i^{US}} E_i^r$$

Aggregation over Time (WinMACCS)

Model parameters

T – duration of disruption in years

t_0 – *base year*

t_I – incident year

$Y(t_0)$ – GDP in the year t_0

$Y(t_I)$ – GDP in accident year t_I

$y(t)$ – GDP at time t

g – GDP growth rate

ρ – social discount rate

Aggregation over Time (cont.)

- GDP for the entire period

$$Total\ GDP\ Loss = \int_{t_I}^{t_I+T} y(t)dt = \int_{t_I}^{t_I+T} exp[(g-\rho)(t-t_I)]dt$$

$$= \frac{Y(t_I)}{(g-\rho)}[\exp[(g-\rho)T] - 1]$$

- Incident year GDP

$$Y(t_I) = Y(t_0)\exp g(t_I - t_0)$$

Treatment of Partially Affected Counties

		By Area	By Population
Industry # 3	Agriculture, forestry, fishing, and hunting	X	
Industry # 6	Mining	X	
Industry #10	Utilities	X	
Industry #11	Construction	X	
Industry #12	Manufacturing	X	
Industry #34	Wholesale trade		X
Industry #35	Retail trade		X
Industry #36	Transportation and warehousing	X	
Industry #45	Information		X
Industry #51	Finance and insurance		X
Industry #56	Real estate and rental leasing	X	
Industry #60	Professional, scientific, and technical services		X

Treatment of Partially Affected Counties (cont.)

		By Area	By Population
Industry #64	Management of companies and enterprises		X
Industry #65	Administrative and waste management services	X	
Industry #69	Educational services		X
Industry #70	Health care and social assistance		X
Industry #75	Arts, entertainment, and recreation	X	
Industry #78	Accommodation and food services	X	
Industry #81	Other services, except government		X
Industry #83	Federal Civilian		X
Industry #85	State and Local Government		X

Conclusions

- Created Input-Output based framework for estimating the GDP impacts of nuclear power plant accidents
  - Calculates impacts on county level for a set of 21 industries
  - Quickly estimates direct, indirect, and total GDP impacts for ad-hoc scenarios
  - Has been integrated with WinMACCS
  - Has been compared with MACCS legacy economic model

Thank you!